AutismCRC

Utilising Robotics Social Clubs to Support the Needs of Students on the Autism Spectrum Within Inclusive School Settings

FINAL REPORT

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QUT

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teaching • challenging • transforming

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Terminology and abbreviations

Because many people on the spectrum reject the use of the term 'disorder' to describe their experience of autism, the authors of this report have chosen to use the terminology 'the autism spectrum', 'students on the autism spectrum' and 'students on the spectrum' when referring to the conditions described in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as 'autism spectrum disorder'. However, the terminology used by the survey participants around autism spectrum disorder has not been altered in the qualitative data sections and is their chosen wording.

The Cooperative Research Centre for Living with Autism (Autism CRC)

The Cooperative Research Centre for Living with Autism (Autism CRC) is the world's first national, cooperative research effort focused on autism. Taking a whole of life approach to autism focusing on diagnosis, education and adult life, Autism CRC researchers are working with end-users to provide practical solutions for governments, service providers, education and health professionals, families and people with autism. Autism CRC aims to solve complex problems with innovative solutions that can only come from having the best minds collaborating as one team – the Autism CRC Team.

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Abstract

Historically, within Brisbane Catholic education schools, robotics social clubs were established by staff to specifically build the pro-social learning skills of students on the autism spectrum. This initiative was in response to the frustration educators would often experience when they observed the subtle gains made by students attending targeted clinical social skills interventions outside the school environment that frequently did not appear to generalise to the social context of the school environment.

Robotics social clubs focus on the strengths and interests (rather than the deficits) of some students on the spectrum and are organised after school or during school lunch times to support students (aged 12-13 years) to work on robotics challenges over 12 one-hour sessions (once a week). The clubs focus not only on promoting the social inclusion of students on the autism spectrum but also on developing the personal and social capabilities of all students involved in the clubs within the real world context of inclusive school settings.

The current pilot study further expanded and evaluated the use of robotics social club interventions to support the inclusion of young people on the autism spectrum in Years 7-8 (12-13 years) within inclusive school environments. Outcomes of the study have included the development of a resource kit and manual to support other teachers who may be interested in implementing a robotics social club within their school or classroom context.

1. Introduction

Students on the autism spectrum attending mainstream school settings are generally ensconced within the broader student population. This immersion can bring advantages such as the behavioural modelling of typically developing peers (Kasari, Locke, Gulsrud, & Rotheram-Fuller, 2011), but it can also provide many challenges for students on the spectrum; for example, the initiating, establishing, maintaining and sustaining of positive relationships with peers (Bauminger & Shulman, 2003).

For students on the autism spectrum, failure to implement social interventions within the school setting and with peers in that setting is an opportunity missed on two counts:

It overlooks the opportunity to target the development of social competence within an inclusive school environment.

It neglects an opportunity for the promotion of inclusive practices.

In a review of social skill intervention studies, Bellini, Peters, Benner and Hopf (2007) identified that programs implemented within the classroom environment and alongside typically developing peers produced significantly better effects than those which relied upon a withdrawal model. Similarly, Barry et al. (2003) identified that social skill programs which included an opportunity to informally interact with typically developing peers resulted in better outcomes than those that did not provide such opportunities.

The need to facilitate the uptake of clinically successful interventions within the inclusive school context is increasingly recognised by researchers (e.g., Parsons et al., 2013). These findings and recommendations are consistent with the inclusive approach utilised in this study and form the rationale for the approach taken.

1.1 USING CLUBS TO BUILD STUDENT SOCIAL SKILLS

Studies using clubs for individual children on the spectrum within different school contexts identify that the utilisation of special interests assists with engagement in and performance by students on the spectrum within the club context (Koegel, Kim, Koegel, & Schwartzman, 2013; Koegel, Vernon, Koegel, Koegel, & Paullin, 2012).

While these studies point the way to the use of the special interests of students on the autism spectrum, these have been limited as they have addressed the engagement and interactions of only one child on the spectrum within one school-based club. Previous iterations of the robotics social clubs in Brisbane Catholic Education (BCE) schools have demonstrated that these clubs provide a context which is highly engaging to both students on the spectrum and, equally importantly, their typically developing peers. The current study further expanded and evaluated the implementation of a robotics social club intervention to support the inclusion of young people on the spectrum within mainstream settings.

The complexity associated with establishing social networks for students on the spectrum cannot be underestimated. Traditional approaches to targeting social skill deficits as a means to increase friendships are based on the premise that 'social skills + autism = successful friendship'. However, the picture is more complicated, as friendships are based on mutual interests, participation and connections and not just on the presence of sufficient social skills.

In typically developing students, peer acceptance, respect and support is important for emotional and behavioural engagement and has been positively associated with academic motivation and with indices of school performance and adjustment (Anderman & Freeman, 2004; Furlong, Cartmel, Biggart, Sweeting, & West, 2003; Goodenow, 1993; Hagborg, 1994; Haynes, Emmons, & Ben-Avie, 1997). Further, a negative association has been found between a lack of engagement and problem behaviour in students in Years 7 and 8 (Fredricks, Blumenfeld, & Paris, 2004; Simons-Morton, Crump, Haynie, & Saylor, 1999). However, not a lot is known about the impact of peer acceptance, emotional and behavioural engagement and problem behaviours in students on the autism spectrum. As a result of past experience at BCE using robotics clubs and the importance of Years 7 and 8 (12-13 years) for students in regard to social relationships and developing positive school engagement in early high school, these year levels were the focus of this pilot study.

1.2 TRANSFERABILITY OF SKILLS TO THE CLASSROOM SETTING

To date, little is known about: 1) the specific skills students learn when participating in robotics social clubs; and, 2) which of these skills are transferred to the classroom setting by either students on the spectrum or their typically developing peers. Given that there is an identified link between peer acceptance, motivation and engagement in typically developing

peers, it is worth measuring these constructs as an outcome measure in both the typically developing population and students on the spectrum who attend robotics social clubs.

Of note, Valentine, Cooper, Bettencourt, and DuBois (2002) have reported that extra-curricular programs can enhance academic engagement and student learning if the program is related to the students' actual school life. Therefore, the current project has investigated the impact of students' participation in the robotics social club on their in-class academic motivation, engagement, and learning and also explored how teachers working in the robotics social clubs could assist classroom teachers in capturing and generalising the learning that occurred within the clubs and further extend them to other contexts within the school environment. To further support teachers and the generalisation of skills learned in the club, this study has developed a manual/resource kit that is accessible to teachers and helps to support their implementation of the program within their individual school context (Lord et al., 2005; Parsons et al., 2013).

1.3 THE CURRENT STUDY

Previous iterations of the robotics social clubs in BCE schools have demonstrated that the clubs provide a context which is highly engaging to both students on the spectrum and, equally importantly, their typically developing peers. This pilot study further expanded and evaluated a robotics social club intervention to support the inclusion of young people on the spectrum within inclusive school contexts.

The project addressed the often perceived barriers to successful intervention in the mainstream school environment through the development of supporting documents and resources in the form of an intervention manual/resource kit that is accessible to help support teachers wanting to establish and implement a robotics social club in their schools or classrooms (Lord et al., 2005; Parsons et al., 2013). In addition, these resources would assist in capturing and generalising the learnings and strategies acquired within the club more broadly to the classroom and whole school context and to support the personal and social capabilities of the Australian Curriculum.

The study sought to build on the resources and experiences which BCE had acquired previously in relation to the use of the robotics social clubs by utilising a participatory action research methodology to address the following research objectives:

1. Evaluate how the robotics social club intervention promotes:
    a. learning of the personal and social capabilities within the Australian Curriculum; and,
    b. peer relationships and academic engagement for students on the autism spectrum within the context of the inclusive school-classroom environment.
2. Identify effective robotics social club strategies that support the generalisation of students' academic engagement and peer relationships to the classroom setting. This would in turn build the confidence and competence of classroom teachers to embed the personal and social capabilities of the Australian Curriculum into their teaching practice.
3. Develop a robotics social club resource kit/manual for dissemination through the Autism CRC that could be a reference and supporting document for schools and individual teachers planning to establish and implement a robotics social club within their school context.

2. Research Design

2.1 RESEARCH METHODS

Given the exploratory nature of this pilot study, a participatory action research design was used based on Timperley and Alton-Lee's (2008) inquiry cycle for developing teacher knowledge and effectiveness (see Figure 1). Using these action research cycles of inquiry through a case study design, the study investigated the implementation of robotics social clubs to support the needs of students on the autism spectrum within inclusive school settings.

As noted in the figure below, there are three cycles of inquiry used in the Timperley & Alton-Lee (2008) approach:

1) Inquiry A – Identifying student needs;
2) Inquiry B – Identifying the learning needs of educators; and,
3) Inquiry C – Identifying the effectiveness of the action from Inquiry A and B in promoting positive outcomes for students.

More details about the each of the cycles of inquiry are provided in Figure 1.

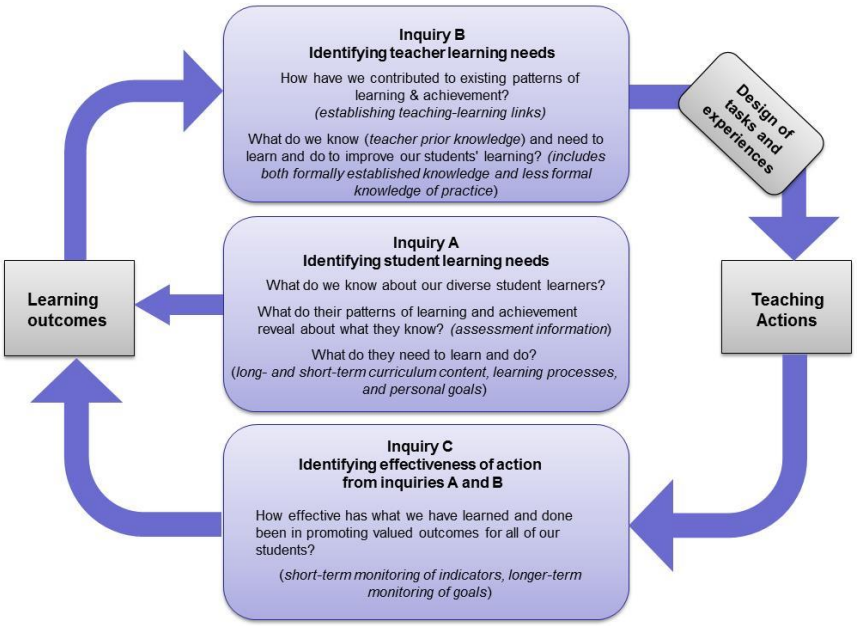


Figure 1. Inquiry cycles for developing teacher knowledge and effectiveness (Timperley & Alton-Lee, 2008).

2.2 RESEARCH QUESTIONS

This exploratory study, utilising a participatory action research methodology, aimed to build on the prior experiences of BCE schools and staff in establishing and implementing robotics social clubs. The following research questions were asked:

1. How do robotics social club interventions:
    a. promote learning of the personal and social capabilities within the Australian Curriculum?
    b. promote peer relationships and academic engagement for students on the spectrum within the school-classroom context?
2. What strategies used in the robotics social club can support the generalisation of students' academic engagement and positive peer relationships to the classroom setting?

Additional aims of the study were:

- To investigate how robotics social club strategies may help to build the confidence and competence of classroom teachers to embed the personal and social capabilities of the Australian Curriculum into their classroom teaching practice; and,
- To develop a robotics social club resource kit/manual for dissemination through the Autism CRC. The aim of this kit is as a reference and support resource for schools planning to establish robotics social clubs.

2.3 RECRUITMENT, PARTICIPANTS AND PROCEDURE

2.3.1 Schools and Teachers

Two Brisbane Catholic education high schools in the northern suburbs of Brisbane, who had previously had contact with a member of the research team in his role as Education Officer, Inclusive Education (i.e., consultant teacher for ASD), expressed an interest in participating in the study.

Characteristics of the schools involved in the study are provided in Table 1. Both schools were co-educational systemic Catholic secondary schools, located in outer suburbs of Brisbane, Queensland. The study was conducted in the first year of Year 7 being moved from primary schools to secondary schools in Queensland, thus all participating students in Year 7 and Year 8 were in their first year of secondary schooling. Contextual information

about the size and composition of each school was collected, and qualitative observations of how the club was implemented in each school were noted to help explain differences in findings between schools.

Table 1 *Characteristics of Schools Involved in the Study*

Characteristic	School A	School B
Total enrolment	302	250
Educational pathways	Mostly VET pathways	OP (academic) and VET pathways
Students verified with a disability	33%	10%
Club facilitating educator	Science teacher, female, experience with students on the spectrum, no experience with Lego robotics	Design and Technology, Graphics, Visual Arts, Maths teacher, male, little experience with students on the spectrum, experience with Lego robotics
Club supporting educator	English teacher, female, experience with students on the spectrum, no experience with Lego robotics	Support teacher for Inclusive Education, male, vast experience with students on the spectrum, no experience with Lego robotics
Club timeline	Wednesday 3:15 – 4:30pm Term 2, Week 7 – Term 3, Week 10	Tuesday 2:45 – 4:00pm Term 2, Week 8 – Term 3, Week 10

School A had no previous experience or exposure to LEGO® robotics, and were provided with six LEGO® MINDSTORMS® EV3 Core Sets for the school to keep to enable their participation. The School Leadership Team invited two early career teachers to facilitate the robotics social club and participate in the study. These teachers were chosen due to their subject areas (e.g., Science and Maths) and/or enthusiasm and interest in supporting students on the spectrum.

School B already owned multiple LEGO® MINDSTORMS® EV3 Core Sets, and had an established robotics club facilitated by a Design and Technology/Visual Arts teacher during lunchtimes which was open to all students. The School Leadership Team invited this teacher to facilitate the more structured robotics social club program and to participate in the study. A few weeks into the robotics social club program, a second teacher was identified and invited to participate due to his voluntary interest in helping to facilitate the club.

2.3.2 Students and Parents

In Term 2 2015, all students in Years 7 and 8 were invited to apply to attend the robotics social club through an announcement in the school newsletter. Students and families were made aware of the associated research project to develop and evaluate the robotics social club program via this newsletter announcement and the general information sheet and consent form that was sent home to all students in Years 7 and 8. This consent form invited participation in the *Motivation and Engagement Scale* (MES) (Martin, 2007) and the *Social Networks and Friendship Survey* (Cairns & Cairns, 1994) at two time points: pre-intervention at the end of Term 2, and post-intervention at the start of Term 4. Both parent consent and student assent were required for participation.

All students on the autism spectrum who expressed an interest in attending the robotics social club were accepted. The Learning Support teams in both schools decided to individually phone the parents of all students on the spectrum in Years 7 and 8 to invite their child's attendance at the robotics social club. Same aged peers who were not on the autism spectrum were accepted according to their order of application (i.e., 'first-in') in School B, and depending on the Learning Support team's judgement of their interest and potential benefit in School A. Students were welcome to attend the club without participating in the research, and this was made clear to students and families.

Students on the spectrum who applied to attend the club, and their families, were invited to an evening information session or contacted individually by the research team, to provide information about participation in the additional components of the study (i.e., student and parent interviews, and the teacher-rated *Social Responsiveness Scale* measuring ASD symptomology (Constantino & Gruber, 2012)), answer questions, and provide an additional information sheet and consent form to be signed by parents and students for participation in these components of the study.

A summary of participants from both schools are provided in Figure 2 (School A) and Figure 3 (School B).

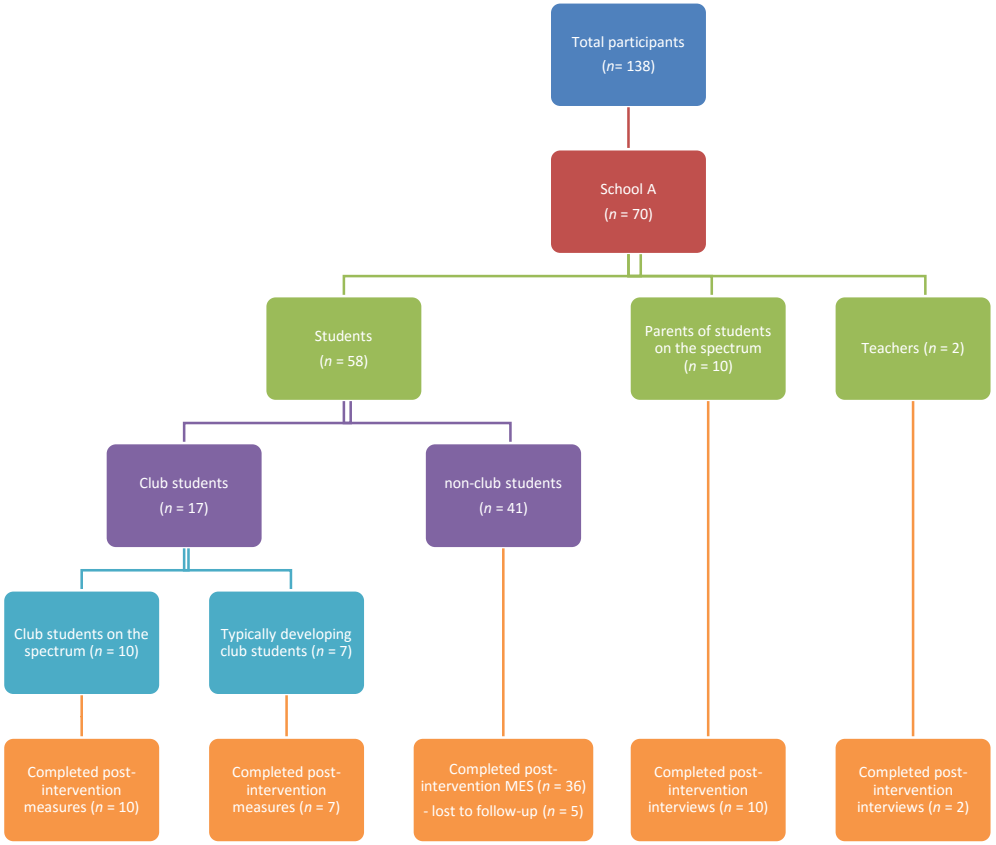


Figure 2. Summary of participants from School A.

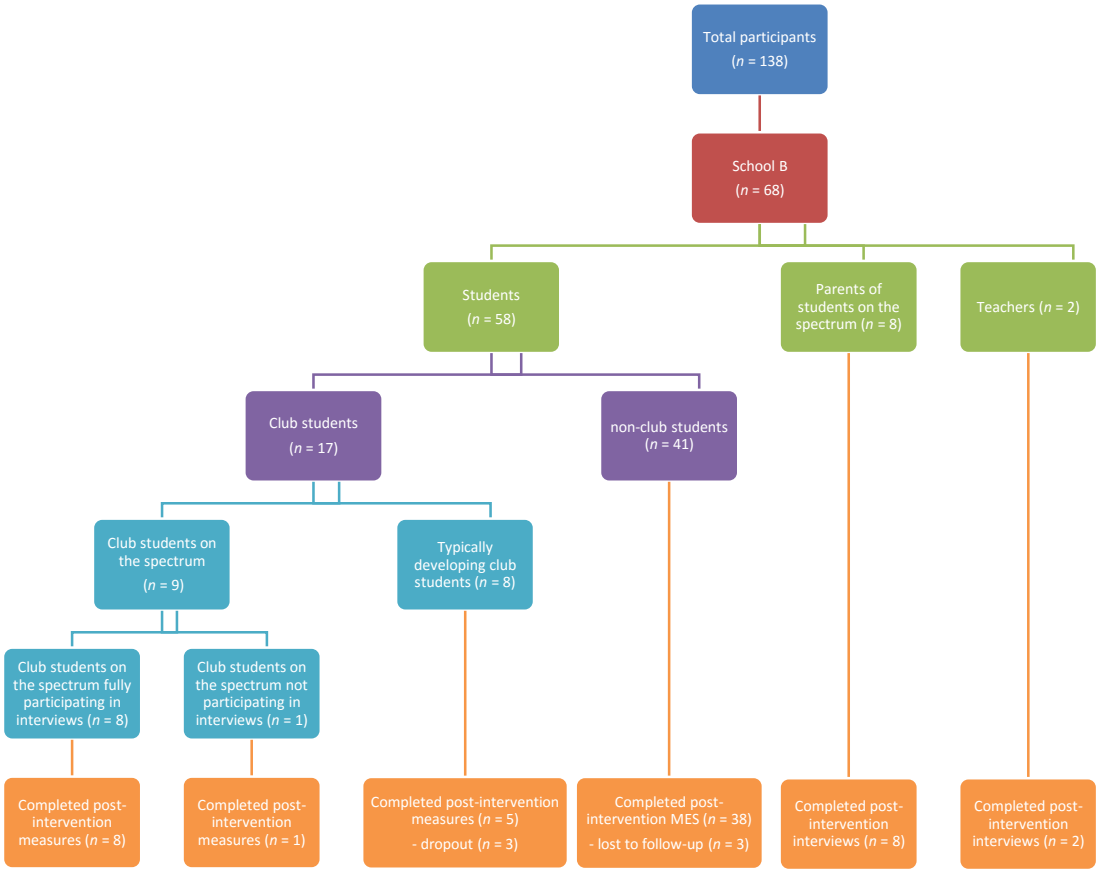


Figure 3. Summary of participants from School B.

2.4 DATA COLLECTION

Data were collected from a range of different participants involved in the study including: students on the spectrum, same aged peers, parents of students on the spectrum, and teachers involved in the robotics social club.

2.4.1 Student Instruments

2.4.1.1 Motivation and Engagement Scale

All students in Years 7 and 8 who provided consent completed the *Motivation and Engagement Scale* (MES) (Martin, 2007) using an online data collection service during class time at pre- and post-intervention time points. The MES is a measure of high school students' academic motivation and engagement, with 44 items rated on a 7-point Likert scale (1 = disagree strongly to 7 = agree strongly; e.g., *'I work hard at school'*). The scale is based on a multi-dimensional model of the thoughts and behaviours that increase and decrease students' motivation and engagement, and provides subscale scores for each of 11 factors. Administration was overseen by the first author in both schools to ensure standardisation of procedures. Items were read aloud and explained to students as necessary to ensure understanding. Participating students were assured of confidentiality and identified via a code to minimise any effect of social desirability in responses.

2.4.1.2 Social Networks and Friendship Survey

All students attending the robotics social club who provided consent completed the *Social Networks and Friendship Survey* (Cairns & Cairns, 1994) at pre- and post-intervention time points; that is, the first and last robotics club session. This measure has been used in numerous studies to capture the social structure of classrooms for both typical and atypical populations (Cairns & Cairns, 1994; Chamberlain, Kasari, & Rotheram-Fuller, 2007; Kasari et al., 2011; Locke, Ishijima, Kasari, & London, 2010). The current study followed the precise method used by Kasari and colleagues (2011). Students were asked to identify which fellow robotics club members they like to hang out with. From the list each student generated, they were instructed to circle their top three friends and place a star next to their best friend. They were also asked to list any students they did not like to hang out with ('rejects'; see Section 2.5.1.2 for details about coding and analysis of this survey). Next, participating students were asked: *'Are there kids in the robotics club who like to hang out together? Who are they?'*. Students listed the names of other students who hung around together in groups;

they were reminded to include themselves in groups as well as to include students of both genders.

2.4.1.3 Social Responsiveness Scale

The *Social Responsiveness Scale* (Constantino & Gruber, 2012) was completed in regards to participating students on the autism spectrum. It is a 65-item measure of ASD symptomatology that reflects the DSM-5 criteria of social communication deficits, and restricted and repetitive behaviours and interests. Scores are described as falling within normal limits, or the mild, moderate, or severe range of the autism spectrum.

In School A, the behaviour of the 10 participating students on the spectrum was rated by the Support Teacher – Inclusive Education (i.e., Learning Support teacher) who was also the students' case manager. In School B, the behaviour of the eight participating students on the spectrum was rated by their respective Pastoral Care teacher at Time 1 and Time 2. Thus, students were rated by five different raters with different levels of knowledge of their students. This was to accommodate each school's preferences and teachers' workload management.

2.4.1.4 Semi-Structured Interviews

Purpose designed semi-structured interview schedules were used to gauge the expectations, experiences and learnings of students on the spectrum who attended the robotics club, at pre- and post-intervention time points. Example questions included, *'What did your experiences in the robotics club teach you?'*, *'Describe the things you enjoyed the most (least) about the robotics club'*, and *'Is there anything you think could be improved about the robotics club?'.* All interviews were conducted by the first author in a private space on each school site, and ranged in duration from 8 to 25 minutes. In an effort to make the interview environment ASD-friendly, students were provided with written questions so they could follow along visually and were aware of upcoming questions; given the option of having the interview audio recorded or not recorded; and a timer was used so that students had an estimation of the amount of time remaining. All students were comfortable with these arrangements, and other modifications and alternative response formats such as conducting interviews via phone or via written responses were not required. Pre-intervention interviews were conducted in June 2015, before the start of the club or after one club session. Post-intervention interviews were conducted in September 2015, after the final club session or with one session still remaining.

2.4.2 Teacher Instruments

2.4.2.1 Semi-Structured Interviews

Purpose designed semi-structured interview schedules were used to gauge facilitating teachers' expectations, needs, learnings, and their perceptions of student outcomes related to implementing the robotics social club, at pre- and post-intervention time points. Example pre-intervention questions included, *'What strategies do you think could be used during robotics club to support the student's demonstration of the personal and social capabilities?'*, and *'What do you perceive as concerns that may arise during the robotics club?'.* Example post-intervention questions included, *'How do you imagine the learnings of the robotics club could be transferred to the classroom setting?'*, and *'What do you think were the positive aspects of the club?'.* All interviews were conducted by the first author in a private space on each school site, and ranged in duration from 30 to 60 minutes. All teachers consented to audio recording of interviews. Pre-intervention interviews were conducted in June 2015, before the start of the club. Post-intervention interviews were conducted in September 2015, after the final club session. In School A, the two facilitating teachers completed both pre- and post-intervention interviews. In School B, the lead facilitating teacher completed both interviews, but the additional teacher was recruited to the study after Time 1 and thus only participated in the post-intervention interview.

2.4.2.2 Teacher Reflections

Participating teachers also completed weekly reflections after each robotics club session. Teachers were prompted to use the Reflection Sheet provided, but had the option to set out their reflections in any way they found most helpful. The lead facilitating teacher in both schools chose to complete the provided template weekly, while the supporting facilitating teacher in both schools used their own formats for reflection. The primary purpose of these reflections were for teachers to use for themselves as a tool to guide their own professional learning process, identify effective and ineffective strategies, and identify ongoing areas of need. Completed reflections were included as collateral data in the qualitative analysis.

2.4.3 Parent Instruments

2.4.3.1 Semi-Structured Interviews

Purpose designed semi-structured interview schedules were used to gauge parents' perspectives of their children's needs, experiences, learnings and outcomes of their participation in the robotics social club, at pre- and post-intervention time points. Example pre-intervention questions included, *'What are your expectations of the robotics club?'*, and *'What do you perceive as concerns that may arise during the robotics club?'.* Example post-intervention questions included, *'Did the robotics club meet your expectations? If so, how?'*, and *'What were some of the benefits of the club for your child?'.* All interviews were conducted by the first author, either via phone or in a private space on each school site. Interviews ranged in duration from 15 to 40 minutes. Pre-intervention interviews were conducted in June 2015, before the start of the club or after one to two club sessions. Post-intervention interviews were conducted in September 2015, after the final club session or with one session still remaining. Many questions included in the student, teacher, and parent interview schedules were similar, in order to achieve triangulation of data between participant groups and between schools.

2.5 DATA ANALYSIS

2.5.1 Quantitative Analysis

2.5.1.1 Motivation and Engagement Scale

Students' academic motivation and engagement was measured at pre- and post-intervention time points to assess for change in motivation and engagement over time and any differences between students in the robotics club (club students), and students enrolled in Year 7 and 8 at each school who were not in the robotics club (non-club students).

Insufficient statistical power and violation of some assumptions prevented the use of parametric tests such as paired-samples *t*-tests. Therefore, frequency data and descriptive statistics are reported and analysed for trends over time between groups and between schools.

2.5.1.2 Social Networks and Friendship Survey

Coding Indegrees, Outdegrees, Significant Connections, Rejects, and Awareness

These variables were coded from the *Social Networks and Friendship Survey*, following the precise method described by Kasari and colleagues (2011). Indegrees were coded as the total number of received friendship nominations – the number of fellow club students who listed the participant as *'someone they like to hang out with'*, whereas outdegrees were coded as the total number of outward friendship nominations by the participant – the number of club members the participant listed as *'someone they like to hang out with'*. Students' significant connections scores were calculated as the total number of students that were significantly linked on the social network map. Each line segment from the social network map indicated a significant connection to a fellow club member from that student. A connection was considered to be significant if the correlation between two students' patterns of who they are perceived to hang out with was equal to or greater than 0.40, as prescribed by Cairns and Cairns (1994). In order to differentiate between weaker and stronger perceived connections, a correlation of 0.60 or greater was considered 'strong'. Social network maps were constructed from this data. Rejects were coded as the total number of times participants were identified as someone other students *'did not like to hang out with'*. Lastly, an additional variable was assessed as part of this study. Awareness was calculated as the number of peers listed by each participant as comprising part of the club's social network. It was hypothesised that due to many students' unfamiliarity with each other at the start of the club, an increase in awareness of peers could be considered a positive outcome.

Coding Social Network Centrality (*Cairns & Cairns, 1994)*

Following Cairns and Cairns (1994), social network analyses were conducted in order to obtain each student's social network centrality (SNC) score within the context of the robotics club. Social network centrality refers to the prominence of an individual in the overall social structure. Three related scores were calculated in order to determine a student's level of involvement in the club's social networks: 1) the student's 'individual centrality'; 2) the 'cluster centrality' of each social group within the class; and, 3) the student's combined 'social network centrality' score. Using methods developed by Cairns and Cairns (1994), the first two types of centrality were used to determine the third. Based on categorisations by Kasari and colleagues (2011), four levels of social network centrality were possible. These four levels of involvement (i.e., isolated, peripheral, secondary, and nuclear) in the club's social structure were coded from 0 to 3, to provide a system for describing how well each participant was integrated into informal peer networks. Students who were considered

'isolated' received a score of 0 for their social network centrality and were not considered part of any cluster of students within the robotics club. Students who were considered 'peripheral' received a score of 1 for their social network centrality and were considered on the outskirts of the club's social structure. These students may have had a few connections to others but were not salient members of the club's social network. Students who were considered 'secondary' received a score of 2 on their social network centrality and were considered well connected members of the club's social structure. Lastly, students who were considered 'nuclear' received a score of 3 on their social network centrality and were considered 'popular' and central members of the club's social structure.

Pre-post comparisons

Due to the small sample size, it was expected that statistical power would be insufficient to run parametric analyses. Thus, trends in frequency data and descriptive statistics were investigated and described; shifts in the social network maps from Time 1 to Time 2 were observed and described.

2.5.1.3 Social Responsiveness Scale

As expected, preliminary analyses confirmed insufficient statistical power to use parametric tests such as a paired-samples *t*-test to assess change in ratings of students over time. Thus, descriptive statistics were analysed for patterns and trends over time and between schools.

2.5.2 Qualitative Analysis

2.5.2.1 Semi-Structured Interviews and Written Reflections

Identifying information such as names were avoided during interviews as much as possible. Identifiable interviews were transcribed verbatim by the first author. Non-identifiable interviews were transcribed verbatim by the first author, Brisbane Catholic Education administration staff, or an external transcription service provider. Interview and reflection data were analysed at a cross-case level of analysis (Patton, 2002), but separated by school and participant group to allow for comparison of between-group and between-school similarities and differences.

The first author conducted a preliminary exploratory analysis (Creswell, 2012) to enhance familiarisation with the data and develop open codes before the formal coding process. The descriptive qualitative technique of content analysis was used to identify and code segments

of text in the interview transcripts relating to the research questions and the three cycles of inquiry (Inquiry A, B and C; Timperley & Alton-Lee, 2008), track the quantity of evidence for each code, reduce the codes by eliminating redundancies, and collapse them into themes representing the predominant concepts within the data (Creswell, 2012; Patton, 2002).

The second and third authors each checked the first author's coding and analysis of a number of interview transcripts to validate the results. They also checked the process of collapsing codes into themes. Quotes that best represented each theme were decided upon mutually. Corroborating evidence for each theme was found between students, parents, and teachers, and between the two schools to achieve triangulation of data (Creswell, 2012) and enhance the validity and accuracy of findings.

2.6 ETHICAL CONSIDERATIONS

2.6.1 Ethics Approvals

Primary ethics approval to conduct the study as outlined in this report was initially obtained from the Queensland University of Technology (QUT). Due to the high risk nature of the student population involved, ethics approval was sought through the National Ethics Application Form (NEAF). Ethics approval through the NEAF was received from the QUT Research Ethics Approval Committee (No. 1500000224). Additional ethics approval was obtained from Brisbane Catholic Education to conduct the study in schools run by this organisation (Approval number 166).

2.6.2 Inclusion

The research team aimed to gain flexible and meaningful participation from the participants. This was achieved using a range of methods. Where possible, all data collection was conducted on a day, date and time that suited the participants in environments of their choice. For student interviews, the students were provided with written questions so they could follow along visually and were aware of upcoming questions; given the option of having the interview audio recorded or not recorded; and a timer was used so that students had an estimation of the amount of time remaining. All students were comfortable with these arrangements, and other modifications and alternative response formats such as conducting interviews via phone or via written responses were not required but available if requested. Items from other measurements were read aloud and explained to students as necessary to ensure understanding. Participating students were assured of confidentiality and identified via a code to minimise any effect of social desirability in responses.

3. Findings

The structure of the clubs as it was implemented in the two schools and the attendance rates of the students participating in the clubs across the 12 weeks are displayed in Table 2 below. Attendance rates were high at all club sessions (>70%) apart from three occasions in School A when attendance was influenced by special events/excursions run by the school.

Table 2 *Club Structure and Attendance*

Week	School A		School B	
	Robotics Challenge	Attendance Rate	Robotics Challenge	Attendance Rate (excluding 4 dropouts)
1	Hit the Target	16/17, 94.1%	Hit the Target	14/14, 100%
2	Driving Test	15/17, 88.2%	Driving Test	13/14, 92.9%
3	Mexican Wave	15/17, 88.2%	Mexican Wave	10/14, 71.4%
4	Commander App Races (not Mexican Wave 2)	15/17, 88.2%	Mexican Wave 2	13/14, 92.9%
5	Escape from the City	12/17, 70.6%	Escape from the City	13/14, 92.9%
6	Sumo	10/17, 58.8% (due to special event)	Sumo	12/14, 85.7%
7	Sumo	15/17, 88.2%	Sumo	11/14, 78.6%
8	Celebrate	8/17, 47.1% (due to special event)	Sumo OR Celebrate	10/14, 71.4%
9	Celebrate	15/17, 88.2%	Celebrate	11/14, 78.6%
10	Celebrate OR Silly Walks	14/17, 82.4%	Celebrate OR Creative	11/14, 78.6%
11	Space Challenge	14/17, 82.4%	Silly Walks	11/14, 78.6%
12	Space Challenge	9/17, 52.9% (due to excursion)	Space Challenge AND Celebrate Showcase	11/14, 78.6%
Average		**77.4%**		**83.4%**

3.1 Social Networks and Friendships

All students in the robotics club completed the *Social Networks and Friendship Survey* before and after attending the 12-week club. The results generated are discussed in the sections following.

3.1.1 Students' Perceptions of Social Networks

3.1.1.1 Social Network Maps

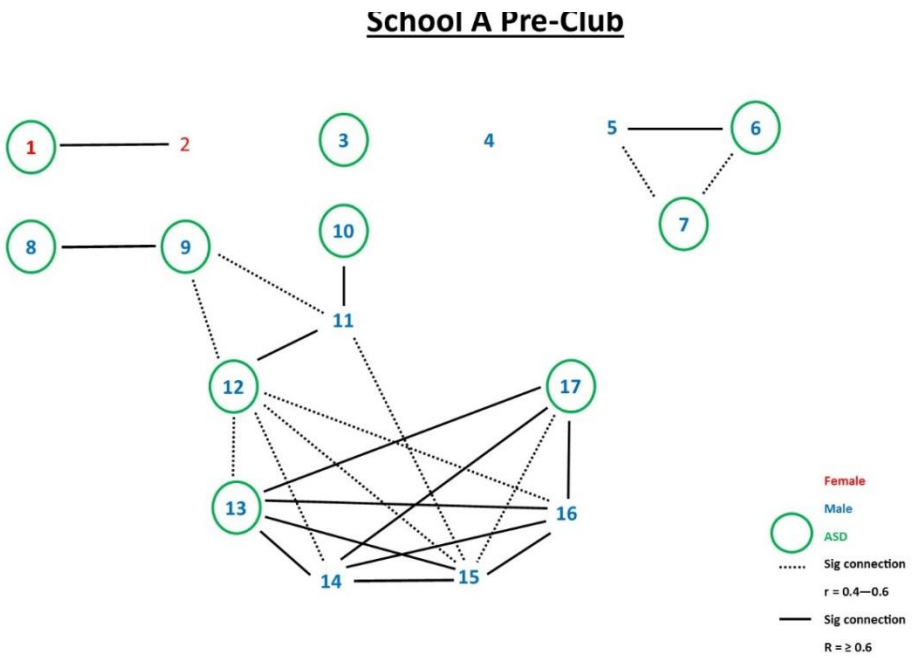
Social network maps were constructed for the group of club students in each school at Time 1 and Time 2. These were constructed based on students' perceptions of the social networks within the group of club students, according to Cairns and Cairns' (1994) method. A connection was considered to be 'significant' if the correlation between two students' patterns of who they are perceived to hang out with is equal to or greater than 0.40, as prescribed in previous research using this method. In order to differentiate between weaker and stronger perceived connections, a correlation of 0.60 or greater was considered 'strong'.

In School B's club, soon after Time 1, four typically developing peers dropped out of the club and therefore the study. Consequently, these participants were excluded from Time 1 analyses to allow for direct comparison between Time 1 and Time 2 connections without the confound of extra participants.

School A's social network maps indicated that students on the spectrum were more likely than their same aged peers to be perceived as isolated at both time points. However, from Time 1 to Time 2, some students (e.g., students 3, 4, 8, and 10) moved from being seen as quite isolated to more integrated, and student 12 was seen to strengthen some existing connections. However, two students (students 7 and 11) were perceived to be more isolated after the club (see Figures 4 and 5).

Interestingly, School B's social network maps appeared to suggest that students had more connections at Time 1, and fewer connections at Time 2. Notably, many of the significant connections identified at Time 2 were new or strengthened. There was no apparent difference between students on the spectrum and their same aged peers (see Figures 6 and 7).

Figure 4. Social network map – School A pre-club.



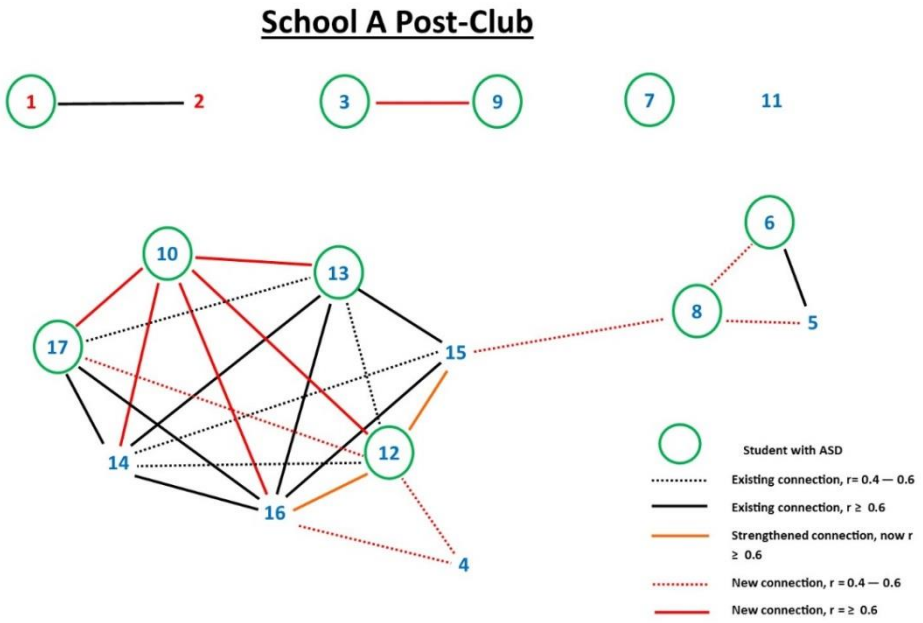


Figure 5. Social network map – School A post-club.

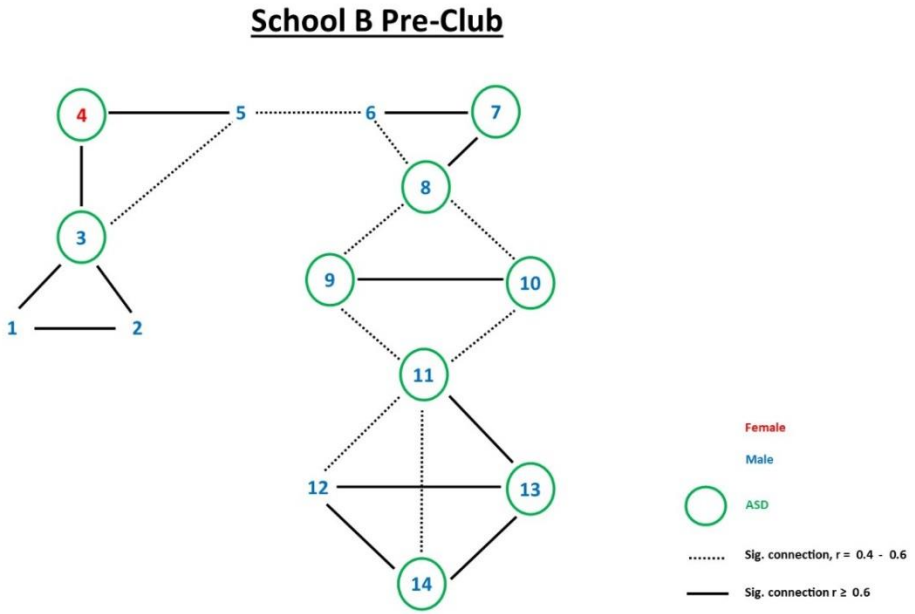


Figure 6. Social network map – School B pre-club.

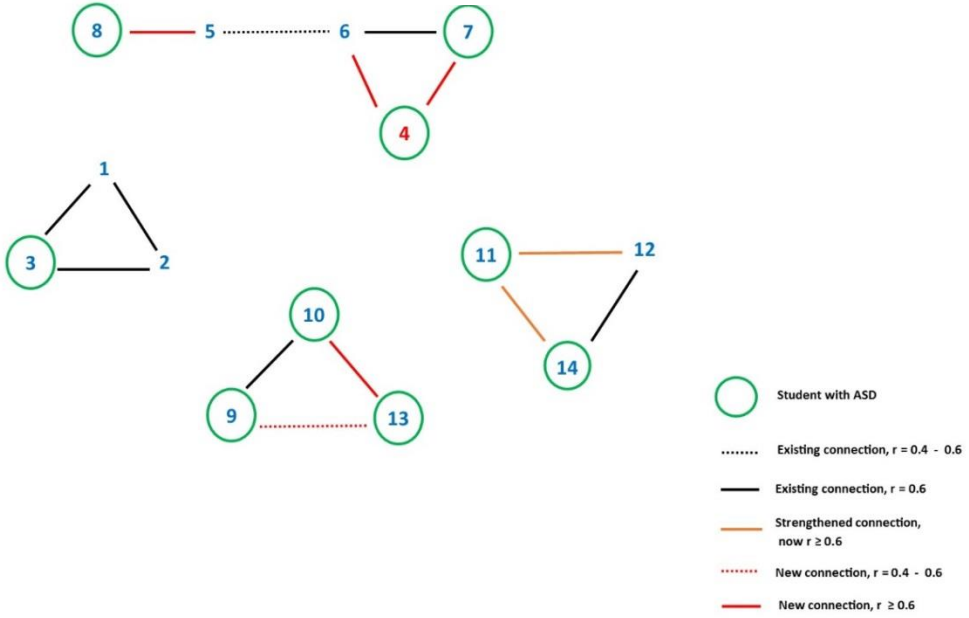


Figure 7. Social network map – School B post-club.

Therefore, rather than forming more connections with peers, it appeared the club encouraged students to establish stronger friendships in more clearly defined groups, perhaps partly as a result of being in the same 'team' within the robotics club for a number of weeks. Both students on the spectrum and their same aged peers appeared to show a similar trend.

3.1.1.2 Social Network Centrality

Social network centrality (SNC) is a measure of each student's prominence or integration within the informal social network of club students. It is calculated based on the number of times a student is named as part of the social network, as well as the prominence of their friendship group or cluster within the club. Overall, 15 students (48.4%) showed no change in SNC categorisation; 10 students (32.2%) showed an improvement; and six students (19.4%) showed a decrease. Of students on the spectrum, eight (42.1%) showed no change in SNC; seven (36.8%) showed an improvement; and four (21.1%) showed a decrease. This compares to the typically developing peers, of which seven (58.3%) showed no change in SNC; three (25.0%) showed an improvement; and two (16.7%) showed a decrease (see Figures 8 and 9). This pattern suggests that students on the spectrum experienced greater benefit in terms of their integration into the social network compared to their same aged peers.

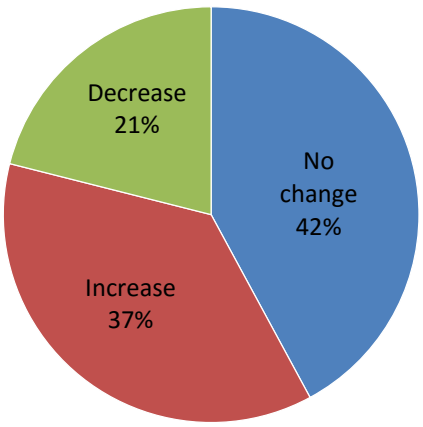


Figure 8. SNC over time for students on the spectrum.

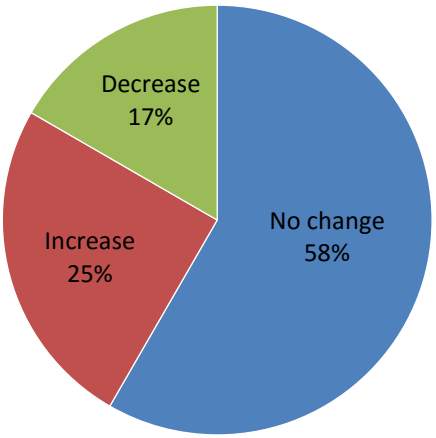


Figure 9. SNC over time for typically developing peers.

3.1.2 Friendship Variables

Participants were also asked to list other students in the club who they liked to hang out with and did not like to hang out with. Due to the small sample size, descriptive statistical analysis of the results was conducted. When separated into students on the spectrum and their same aged peers categories (see Table 3), the trends suggest that students on the spectrum experienced greater benefits than their peers in terms of an increase in the number of students they liked to hang out with, and a decrease in the number of times they were 'rejected' by peers. This is because of the higher number of 'rejections' compared to their peers at Time 1, with a comparable number of 'rejections' to their peers at Time 2. However, this trend appears to be driven by School A. Both students on the autism spectrum and their same aged peers showed a comparable increase over time in the number of nominations by peers, a trend that was consistent across schools. However, while both groups tended to name more peers in the social network (and thus be more aware of the social structure) at Time 2 compared to Time 1, same aged peers showed a greater increase in this awareness compared to students on the spectrum. This is to be expected given that individuals on the spectrum often have identified difficulties with social awareness, such as awareness of peer networks and even peers' names. Thus, the small observed increase may be more clinically meaningful than the data suggests. Overall, these trends support those revealed by students' social network centrality, suggesting that students on the autism spectrum showed somewhat greater benefit in terms of their integration and acceptance into the social network of the club compared to their same aged peers.

Table 3 *Social Networks and Friendship Variables*

Measure	Students on the Spectrum (*n* = 19)		Same Aged Peers (*n* = 12)	
	Pre	Post	Pre	Post
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Peer Nominations (Outdegrees) – the number of students named as someone the participant likes hanging out with	3.58 (2.19)	4.95 (3.69)	3.00 (1.48)	3.75 (1.29)
Nominations by Peers (Indegrees) – the number of times a participant was named as someone others like to hang out with	3.00 (2.21)	4.37 (2.91)	3.58 (2.23)	4.42 (2.50)
Rejections by Peers (Rejects) – the number of times a participant was named as someone others do not like to hang out with	3.53 (1.84)	1.95 (1.35)	2.42 (1.78)	2.17 (1.95)
Significant Connections – the number of significant connections with other club students, as represented in the social network maps	2.79 (1.58)	2.53 (1.87)	3.00 (1.76)	2.83 (2.08)
Peers Named in Social Network (Awareness) – the number of students named by a participant as belonging to the club's social network, intended as a measure of awareness of peers and the social structure	3.21 (2.97)	4.05 (3.10)	2.58 (2.31)	7.08 (2.97)

3.1.3 Motivation and Engagement

Students' academic motivation and engagement was measured before and after attending the 12-week robotics club. This was done to assess for changes in motivation and engagement over time as well as to compare any differences which may be evident between students attending the robotics club (club students), and students enrolled in Year 7 and 8 at each school who were not attending the robotics club (non-club students). Figure 10 provides a visual representation of the subscales comprising the *Motivation and Engagement Scale* (MES).

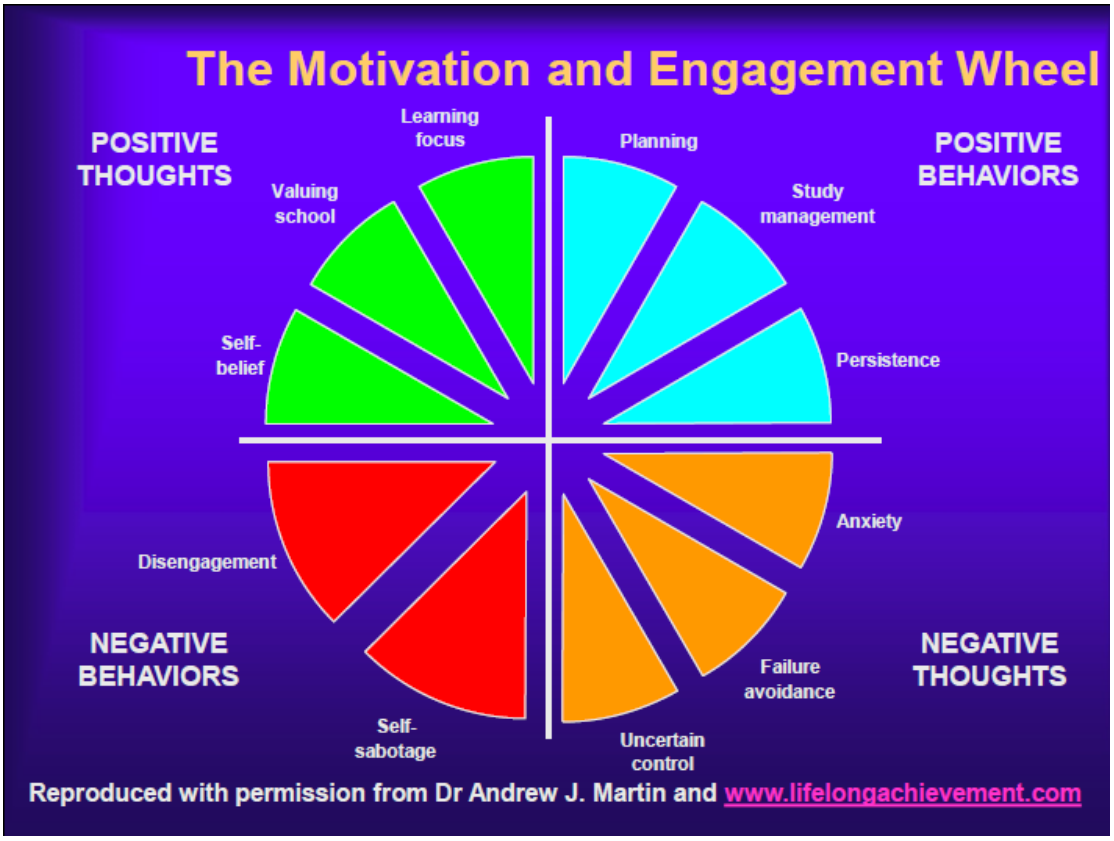


Figure 10. The Motivation and Engagement Wheel (Martin, 2007).

Thirty club students and 74 non-club students completed the MES at Time 1 and Time 2. Descriptive results are provided in Table 4. While the trends described are not statistically significant, this does not prevent them from being clinically significant.

3.1.3.1 ‘Booster’ Factors

In relation to ‘booster’ factors (that is, self-belief, valuing of school, learning focus, planning, task management, and persistence), the data suggest that overall club students were less likely to show a decrease from Time 1 to Time 2 compared to non-club students. This pattern of results suggests the club may have had a positive effect on students’ motivation and engagement by buffering against some of the expected drops in ‘booster’ factors over time as students get older.

3.1.3.2 ‘Muffler’ and ‘Guzzler’ Factors

In relation to ‘muffler’ and ‘guzzler’ factors (that is, anxiety, failure avoidance, uncertain control, self-sabotage, and disengagement), the data suggest that on the subscale of anxiety, both club and non-club students were similarly likely to show an improvement (i.e., a decrease) in anxiety levels from Time 1 to Time 2. However, this seems driven by School A, whereas School B students’ anxiety levels remained steady. Overall, on the subscales of failure avoidance, uncertain control, and self-sabotage, School B students generally showed steady trends on these variables over time. In School A, both club and non-club students showed an improvement on failure avoidance, but only non-club students showed improvement on uncertain control and self-sabotage. Frequency data suggest club students in both schools appeared to remain steady or demonstrated apparent movement in both directions, and continued to be more likely to report difficulties compared to non-club students.

Interestingly, on the disengagement subscale, descriptive data suggest no change over time for either club or non-club students. However, frequency data reveal a different pattern. Club students who reported being disengaged at Time 1 appeared to show an improvement and increased engagement at Time 2, whereas non-club students were more likely to show a drop in engagement. This trend was consistent across schools. This suggests the club may have a positive effect on engagement by buffering against the expected drop in engagement over time, and perhaps even helping to increase levels of engagement in the most vulnerable students.

Table 4 *Motivation and Engagement Scale Scores – Collapsed Across Schools*

Subscale	Club Students (*n* = 30)		Non-Club Students (*n* = 74)	
	Pre	Post	Pre	Post
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Self-Belief	93.90 (18.98)	98.93 (15.97)	97.68 (16.97)	96.08 (18.73)
Valuing of School	98.43 (18.31)	97.33 (18.33)	100.91 (13.56)	96.22 (18.18)
Learning Focus	95.10 (20.84)	93.13 (18.03)	99.66 (17.31)	95.96 (21.89)
Planning	93.90 (15.48)	94.27 (16.11)	96.86 (17.06)	95.03 (18.56)
Task Management	97.73 (14.18)	96.87 (16.46)	97.23 (15.06)	95.92 (16.10)
Persistence	96.90 (19.07)	98.50 (14.89)	96.46 (18.85)	93.86 (19.24)
Anxiety	102.37 (15.23)	99.47 (15.93)	101.31 (14.99)	98.47 (17.39)
Failure Avoidance	107.07 (18.43)	105.33 (19.24)	101.73 (16.90)	99.58 (15.88)
Uncertain Control	103.83 (15.99)	103.37 (17.15)	100.96 (14.14)	98.27 (14.91)
Self-Sabotage	100.27 (15.14)	100.20 (15.72)	100.46 (15.65)	97.20 (15.06)
Disengagement	100.73 (15.75)	100.73 (16.19)	99.00 (14.19)	100.51 (15.76)

Note: Scores are reported as 'Motivation Quotients', standardised scores with a mean of 100 and standard deviation of 15, normed against the standardisation sample for 12-13 year olds or 14-15 year olds. On the 'booster' scales of self-belief, valuing of school, learning focus, planning, task management, and persistence, higher scores indicate higher levels of motivation and engagement; on the 'muffler and guzzler' scales of anxiety, failure avoidance, uncertain control, self-sabotage, and disengagement, higher scores indicate lower levels of motivation and engagement.

3.1.4 ASD Symptomatology

The *Social Responsiveness Scale – Second Edition* (SRS-2) (Constantino & Gruber, 2012) was completed for the 18 participating students on the autism spectrum. In School A, the 10 participating students' behaviour was rated by the Support Teacher – Inclusive Education (i.e., Learning Support teacher), who was also the students' case manager. In School B, the eight participating students' behaviour was rated by their Pastoral Care teacher at Time 1 and Time 2. This resulted in students being rated by five different raters with different levels of knowledge of the students. This was to accommodate each school's preferences and teachers' workload management.

The descriptive results revealed substantial differences between schools. In School A, students' scores decreased in severity from Time 1 to Time 2 across all subscales, excluding the restricted, repetitive behaviours subscale. That is, ratings of students on the spectrum in School A indicated improvements in social communication skills after participating in the club, including social awareness, social cognition, social communication, and social motivation. In contrast, School B students' scores remained steady or increased in severity from Time 1 to Time 2 across all subscales. This apparent interaction effect was dependent upon the school and indicated that, in general, mean scores for School A students moved from the moderate range pre-club to the mild range post-club, whereas mean scores for School B students moved from the mild range pre-club to the moderate range post-club. Perhaps this large difference in trends between schools may be explained by the differences between raters of the SRS-2.

Table 5 *Social Responsiveness Scale Scores – Separated by School*

Subscale	School A (*n* = 10)		School B (*n* = 8)	
	Pre	**Post**	**Pre**	**Post**
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Total	67.90 (13.88)	62.20 (12.70)	64.75 (13.78)	68.75 (9.62)
Social Communication Index	68.00 (12.86)	61.40 (11.86)	64.13 (12.89)	68.50 (9.70)
Social Awareness	57.30 (14.17)	54.90 (14.08)	63.50 (11.81)	64.13 (12.16)
Social Cognition	72.30 (9.46)	60.80 (7.97)	63.63 (14.67)	68.00 (10.70)
Social Communication	66.80 (13.69)	61.20 (12.35)	65.13 (13.07)	69.50 (9.91)
Social Motivation	66.70 (12.72)	62.00 (11.61)	57.00 (8.00)	62.00 (7.76)
Restricted, Repetitive Behaviours	64.10 (16.30)	63.40 (15.06)	64.13 (14.84)	67.38 (11.15)

Note: Scores are T-scores with a mean of 50 and standard deviation of 10. T-scores of 60 to 64 indicate mild levels of ASD symptomatology; 65 to 74 indicates moderate levels; and 75 or above indicates severe levels.

3.2 Qualitative Results

Qualitative data from interviews conducted with the teachers involved in the clubs, the students on the spectrum and their parents, across the two schools, was broadly organised into a number of categories. Within each category a number of themes emerged. Figure 11 provides a summary of the categories and themes which emerged at Time 1 and Time 2.

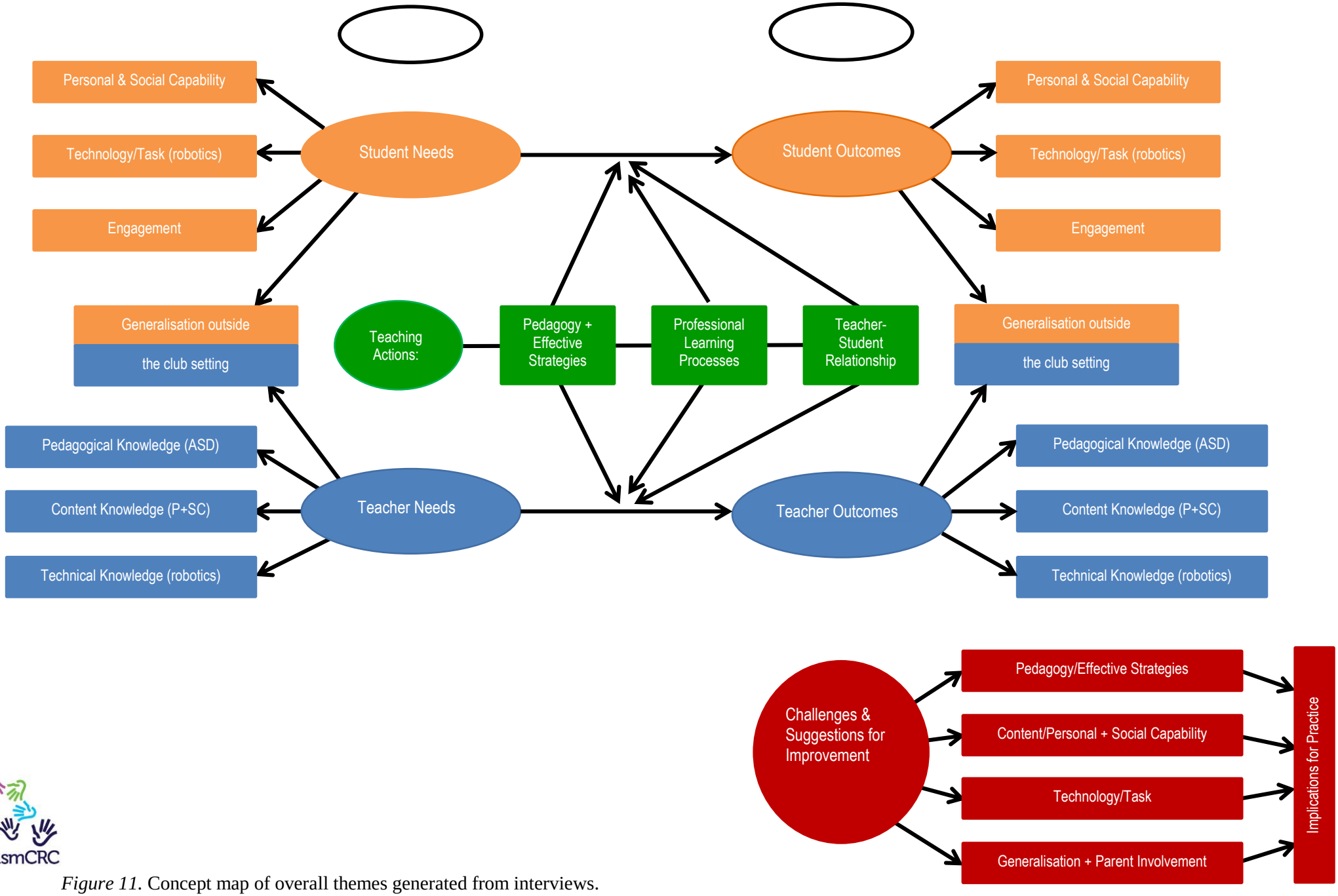


Figure 11. Concept map of overall themes generated from interviews.

3.2.1 Time 1 Categories and Themes

Two key categories were generated for qualitative data at Time 1 interviews. The Time 1 interviews occurred prior to the club commencing. The categories that were generated from the data represented expectations interviewees had of student and teacher involvement coming into the clubs. The categories that emerged included: 1) student needs; and, 2) teacher needs. Within each of these categories a number of key themes and sub themes emerged.

3.2.1.1 Time 1 – Category 1: Student Needs

The first Time 1 category to emerge was student needs. This category reflected the areas of student need that interviewees felt the club could support. Within the student needs category three key themes emerged from the data (see Table 6 for more details). These themes included supporting student needs in relation to: 1) personal and social capabilities; 2) student engagement; and, 3) task/technology. Contained in each theme were a number of sub themes. These are outlined in more detail in Table 6.

These sub themes highlighted expectations that the club would help to support the students' ability to socialise by helping to them to: develop the skills needed for teamwork; increase their confidence, allow them a sense of success and support their leadership skills; support their resilience and ability to deal with frustration; increase their self-awareness and independence; and, help the student to get to know others and make friends.

In relation to supporting student engagement, the sub themes highlighted expectations that the club would help students to: enhance student-student relationships; see the relevance to job and career interests; develop life skills and have fun; and, increase their co-curricular involvement and encourage generalisation to classroom and playground.

From a tasks and technology perspective, it was hoped participation in the club would increase the students' building, programming and technological skills and enhance their creativity and problem solving skills.

Table 6 *Themes Emerging from Student Needs Category*

Theme	Sub Theme	Supporting Quotes
Personal and Social Capabilities (that is: Social Management, Self-Management, Self-Awareness and Social Awareness)	Teamwork skills (being cooperative, helpful, friendly, patient, sharing, communicating, listening) (Social Management)	**Student AS02, Male, Year 8:** 'I don't really have much experience working with people that good. Because I always take over a little bit. So it will probably teach me to work more as a team.' **Teacher AT02:** 'I hope they figure out that, "Actually, I'm better as a team, rather than just going it alone."' **Parent BP07:** 'Being tolerant of other people. Getting along, sharing ideas, cooperating, listening and respecting their input. It's an opportunity to work with others on the same level.'
	Confidence, sense of success, leadership skills (Self-Management)	**Teacher AT01:** 'I think some of them in the group will shine, and it will be an absolutely fantastic thing for them, to see how they can work to help others and to be a leader. Because in other areas of school they just don't have that.' **Parent BP03:** 'I hope his shine and enthusiasm can come through by using his interests. Robotics club will be an opportunity to be a leader, contribute, achieve, and develop confidence.'
	Resilience, dealing with frustrations (Self-Management)	**Student AS09, Male, Year 8:** '[It might] help me not to yell at people when they get it wrong! [laughs] …Teach me how to stay calm if they get it wrong.' **Teacher AT01:** 'Hopefully [they will learn] how to work together, but also a bit of resilience … I'm hoping they will be given some confidence to have an idea and put it forward.' **Parent AP05:** 'Hopefully, some self-control, and greater awareness of others. Being able to cope and function in a social environment, and taking responsibility for problem-solving himself.' **Student BS04, Male, Year 7:** '[I think I will learn] that if you fail you can just keep on trying. It doesn't mean you lose. You keep on doing it.'
	Self-awareness, independence (Self-Awareness)	**Teacher BT01:** 'Independence, and their relationships with other kids. Maybe they can look at themselves a little bit more about how they're communicating with each other, how they're getting along with each other, how their behaviour is towards other kids, maybe how they talk to other kids. Just be a little bit introspective I guess.' **Parent BP02:** 'Helping her identify that it's about getting the job done, rather than the emotions and the social drama. For her to consider, "Is what I'm doing helpful or unhelpful?"'
	Get to know others, make friends (Social Awareness)	**Student AS08, Male, Year 8:** '[It might teach me] that I can make new friends. I'm not by myself and there's other people by my side who want to be my friend and help me.' **Teacher BT01:** '[The positives will be] just building relationships between the kids, you know. Seeing them flourish and trying all this stuff on them, so they're able to realise these things for themselves.' **Parent BP04:** 'I suppose ideally we'd like him to form some new friendships, and be able to maintain them across time. So it's probably that initial forming friendships with like-minded children … increasing the size of his social circle, and learning how to fit in with other types of children.'
Engagement	Student-student relationships: Get to know others, make new friends	**Student AS06, Male, Year 8:** '[I'm looking forward to] getting to meet more new people … also learning how to work with your friends.'
	Relevance to job/career interests, life skills	**Student AS02, Male, Year 8:** 'I wanna join the police force, so I think it would teach me, um, teamwork and how to work with other people … A lot of people in school say that, "Oh school is stupid, it's not going to help you outside of school." But that's why I do it, because it is going to help you, because a lot of jobs do use a lot of the stuff that you do.' **Student BS08, Male, Year 7:** 'Possibly [it could teach me] skills for later in life … to learn to get along and work with other people and job partners … job skills, because I've been planning and hoping that someday I might get some engineering or mechanical electrics job.' **Parent BP02:** '[I hope] that it might open her eyes to possible careers in programming and related fields, as she could be suitable for this work.'

	Have fun	**Teacher AT01:** 'Wednesday will just be their favourite day of the week, because they'll be using the robot and the Lego.' **Student BS08, Male, Year 7:** '[I'm most looking forward to] probably the whole thing, but mostly build and design … just because it sounds like it will be a lot of fun.' **Parent BP04:** 'I think the fun aspect is a big sell for him. Fun is important.'
	Co-curricular involvement	**Parent AP03:** 'It will be good for him to have an after-school activity, other than Scouts … he is quite solitary and doesn't make friends easily.'
	Generalisation to classroom and playground	**Teacher AT01:** 'In the playground, that's where they struggle the most in terms of social skills, and just lacking confidence to do anything from standing in line at tuckshop to playing a casual game.' **Parent BP02:** '[I hope] that she will function more successfully in group work, and this could have a flow-on effect for her marks in schoolwork … and engaging in deeper learning through the process.'
Task/Technology	Building, programming and technological skills	**Student AS03, Male, Year 8:** '[We will need to do] lots of programming. Building design structures, and challenging ourselves.' **Parent BP01:** 'I would hope that it might help him with his interest maybe in programming, and help if you do things with the planning, help with the understanding that planning can actually be useful.'
	Creativity and problem solving skills	**Parent AP09:** 'I kind of like the whole "okay try it, it didn't work, so fix it", because that's a problem solving skill, because that's something we face in our lives you know you do things and they don't work, and you know you do have to go and try something else so I think him having to learn to deal with that and working with other people to deal with those problems.' **Student BS06, Male, Year 7:** 'I think it will give me more imagination and creativity … it will teach me what I'm good at.'

3.2.1.2 Time 1 – Category 2: Teacher Needs

The second category to emerge at Time 1 was teacher needs and reflected what the teachers felt they needed to do or have more knowledge about to effectively implement the club and meet the aims of the club. Within this category, four key themes emerged from the data (see Table 7 for more details). These themes included: 1) pedagogical knowledge; 2) content knowledge; 3) technological knowledge; and, 4) generalisation, and represent expectations teachers had of participation in the club prior to it commencing. Contained in each theme a number of sub themes surfaced and these are outlined in Table 7 in more detail. These sub themes highlighted that teachers had a desire to learn new pedagogical practices. They felt there were a number of strategies they would need to use when running the club; for example, use explicit instruction, breaking down tasks, and providing structure and routines. Other strategies they highlighted included the use of:

- visual supports,
- prompting, coaching, reflection,
- modelling,
- positive reinforcement and feedback,
- practice and repetition,
- providing a safe environment, and
- teaching confidence and encouraging self-efficacy.

Content knowledge focussed on an expectation that some existing knowledge of the personal and social capabilities existed and would be utilised, while technological knowledge expectations highlighted the need for teachers to be supported in their technological and content knowledge to help the club be successful. In comparison, generalisation expectations highlighted the importance of generalising the student learning from the club to both the classroom and playground. Expectations of generalisation to other teachers' practice included that this could be through:

i. staff meetings,
ii. the sharing of case studies of students,
iii. peer observation and mentoring, and
iv. informal conversations.

Table 7 *Themes Emerging from Teacher Needs Category*

Theme	Sub Theme	Supporting Quotes
Pedagogical Knowledge	Explicit instruction, breaking tasks down	**Teacher AT02:** 'I think "explicit" should be our key word, our key mantra for this entire project … chunk it down, be very explicit about what you want.'
	Structure and routine	**Teacher AT01:** 'Every week in their head they'll have the same routine … so they know the routine to expect each week, I think that will be really good.'
	Visual supports	**Teacher BT01:** 'I'd structure things, I'd write things down and maybe work out strategies and worksheets and diagrams.'
	Prompting, coaching, reflection	**Teacher BT01:** 'Listen in on the conversations that are going on between the kids, are they working collaboratively, negotiating, resolving issues … and then pull the kids in or talk to the kids, "Maybe you could do this …" Intervene … And just keep reminding them.'
	Modelling	**Teacher AT02:** 'I like that we've got the video embedded at the start. I think most teachers can come to an agreement that modelled practice is the best way to go about anything. So that very traditional "I do, we do, you do" model works really well.'
	Positive reinforcement, feedback	**Teacher AT02:** 'Praise language, positive feedback, but I would never draw attention to their negative feedback.'
	Practice, repetition	**Teacher AT01:** 'Just giving them an opportunity to show those steps, where they just don't have that in other places at school … that practice and repetition.'
	Safe environment	**Teacher AT02:** 'Because they're in a fun environment and hopefully with friends … I hope they feel it's safe enough that they can take risks.'
	Teaching confidence/self-efficacy	**Teacher AT01:** 'Am I going to know how to run a session, and be good at it? … I really like the booklet with reflections and things. That's good because I know what to do at each step … to have as a reference during sessions. Just as a reassurance thing I guess.'
	Desire to learn new pedagogical practices	**Teacher BT01:** 'You get all these lists of kids who have these issues, and it can just be daunting sometimes to think you've got to pay attention to eight individuals in a class, and let's just forget about all the others, do you know what I mean? So maybe from this we could get some ideas for easy, workable solutions to helping these kids achieve these things. That would be good.'
Content Knowledge	*Some* existing knowledge of personal and social capabilities	**Teacher AT01:** '[I'm aware of] some of, not all of it … I can't remember off the top of my head.' **Teacher AT02:** 'When I found out about the Club being more focused on the emotional capabilities and social capabilities, I think that's something we could definitely be working on! … I understand that, pardon the pun, but Lego robotics is just a vehicle for teaching those capabilities.' **Teacher BT01:** '[I'm aware but can't recall] … See all this stuff, you sort of automatically do. It's already there. It just seems to be one of those policies or things again that someone's come up with that, you know what I mean, it's a great idea but you're already doing it.'
Technological Knowledge	Need for support with technological/content knowledge	**Teacher BT01:** 'I think the kids can really pick up on it if you don't have the confidence when you're trying to deliver something like robotics. So, you really have to do your homework about how you do things, because otherwise they'll catch on straight away. You have to do it with conviction, and that can be quite hard if you have not had prior experience … I think without [a mentor] there by your side when you first start, it would be … unless you were given a month to just go away and learn it yourself, and have 10 activities planned ahead of time … That booklet you brought in, you can't find anything like that anywhere. So that's really good, how it has that step-by-step sequence of activities. It's perfect.'

Generalisation	Of pedagogy to the classroom and playground	**Teacher AT01:** 'If we can see a skill or something that promotes that on a Wednesday in the Club, and then take that into class I think that would be really good. Definitely one of the goals.' **Teacher AT02:** 'I think it would be fantastic to see [how to teach] something so abstract as personal and social capabilities, that just get glossed over, because how do you teach conflict resolution to 20 Year 7s with ASD?! [laughs] That's a good challenge! So if you can apply these strategies to something so abstract … if it works then, it's going to work in my classroom.'
	Staff meeting	**Teacher AT01:** 'Hopefully we do a staff meeting debrief of what we did in the Club, and what we noticed.'
	Sharing case studies of students	**Teacher AT01:** 'Maybe if we did a little report up on some of the kids as case studies, and say, "We've noticed this skill works really well for him … this is the kind of environment they've got, this is where they flourish."'
	Peer observation/mentoring	**Teacher AT02:** 'Maybe that's something that could be useful, "Hey do you know how to structure a really good lesson for students with ASD? Do you know how to differentiate for students with ASD? Do you know how to use your language for students with ASD?" Maybe the club can be a springboard for that.'
	Informal conversations	**Teacher BT01:** 'In a meeting, or just drip feed via email, talk about it … that's the thing, people are so hard-pressed for time.'

3.2.2 Time 2 Categories and Themes

Three key categories were generated for qualitative data at Time 2 interviews. These represented reflections interviewees had of student and teacher involvement in the club. The categories that emerged included: 1) student outcomes; 2) teacher outcomes; and, 3) challenges and suggestions for improvement. Within each of these categories a number of key themes and sub themes emerged.

3.2.2.1 Time 2 – Category 1: Student Outcomes

The first Time 2 category to emerge was student outcomes. This category reflected the identified outcomes as perceived by interviewees for participants on the autism spectrum as a result of their involvement in the club. Similarly to the Time 1 category of student needs, three key themes emerged from the data (see Table 8 for more details). These themes included: 1) personal and social capabilities; 2) engagement; and, 3) task/technology. Contained in each theme a number of sub themes surfaced. These are outlined in more detail in Table 8.

Overall, the perceived benefits of the club for the students involved included improvements in: teamwork skills, confidence, having a sense of success and leadership skills. In addition, it was perceived that it enhanced resilience and improved skills in dealing with frustrations, improved self-awareness of strengths and difficulties, and increased students' knowledge of others and the development of friendships. It was perceived that increased engagement as a result of the club was evident through: improved student-student relationships, the students' enjoyment of robotics tasks, and the obvious relevance to job and career interests. In addition, life skills were learned, and there was evidence of generalisation to classroom and playground. It was also evident that building, programming and technological skills were learned and creativity and problem solving skills were improved.

Table 8 *Themes Emerging from Student Outcomes Category*

Theme	Sub Theme	Supporting Quotes
Personal and Social Capabilities (that is: Social Management, Self-Management, Self-Awareness and Social Awareness)	Teamwork skills (being cooperative, helpful, patient, sharing, communicating, listening, caring, compromising making decisions, including others) (Social Management)	**Student AS08, Male, Year 7:** 'I got to know people and I had to learn how to communicate and share and like not just be selfish and hog stuff … [it taught me] to be a better person and not just tell people what to do, you also have to think of what they are thinking …. You have to sometimes agree with what they want … not boss them around and let them share their ideas and let them join in and not exclude them or let them be left out.' **Teacher AT01:** 'Supportive – that's probably a word I would use to describe the club, in different capacities. Seeing them support each other has been really nice.' **Parent BP02:** 'I think she's learnt more complicated social skills … I think it's helped her with some of those more middle-of-the-road friendships – relationships, where it doesn't have to be "oh you're my super best friend". So I think she's gained maturity in friendships and appreciated some more subtle aspects of relationships, and towards that, working relationships.'
	Confidence, sense of success, leadership skills (Self-Management)	**Student AS01, Female, Year 8:** '[I learned] that I can do new stuff … that I can do anything.' **Teacher AT01:** 'I think they're noticing in robotics that [time management] is a strategy and they have started to do that in class and actually saying, "I'm not going to get this finished" … which I know is something so simple, but it's huge for them – huge … so having them come back with those little successes that they can do it.' **Parent AP06:** 'It's good for kids who don't have success in other areas, a chance to let these kids shine. Also the way it's with other like-minded kids, it shows them the there are others like me as well.' **Student BS03, Male, Year 7:** 'I never really knew I could do that … I never knew I could be that skilled with Lego … I was surprised to see that.'
	Resilience, dealing with frustrations (Self-Management)	**Student BS07, Male, Year 8:** '[I learned] to try to get along with people harder … Like when someone snapped at me, I wouldn't get angry with them, I just walk away.' **Teacher BT01:** 'I noticed a big difference actually with [student]. He was always just bossy and loud … Whereas now I think he knows to ask nicely when he wants something. I've really noticed with him, and that sort of thing, going to the Club has worked for him in that way … he is definitely calmer, which is good.'
	Self-awareness of strengths and difficulties (Self-Awareness)	**Student AS06, Male, Year 8:** 'Probably [taught me] to be a bit more patient, and be a bit more gentle … like, if someone wants to do it and it's not exactly how you would do it, let them do it.' **Student AS10, Male, Year 8:** 'I like being in groups, it makes me feel better than being by myself. Rather than feeling alone, like I have no help. If I get an idea, I understand it easier. I learn by watching and communicating with other people. That's how I learn and know what to do.' **Student BS05, Male, Year 8:** 'The book they do at the end of the week, I reckon they should continue with that. It was helpful 'cause then you could know, like you were ticking off boxes saying I was this and this and this, and I reckon that was good for confidence.'
	Got to know others, made friends (Social Awareness)	**Student AS07, Male, Year 8:** 'After [the club finished], I kind of knew everyone. Like probably half the kids I don't quite know properly. We made groups with some of the people we didn't know, [so I] got to know them better.' **Student BS03, Male, Year 7:** '[I learnt that other people] can also be kind of helpful but mostly they just, mostly sometimes they just get in my way.' **Parent BP05:** 'I think he started mentioning boys' names that I hadn't heard before, so to me, that is probably a great bonus of the whole thing. That children became – other mates became more common knowledge to him. Or we'd pass, someone would say "hey", and he goes, "oh, that so-and-so from robotics". I'm like, cool. It's working.'
Engagement	Student-student relationships: Get to know others, make new friends	**Student AS10, Male, Year 8:** 'It's really fun to get along with people and join in and be friends with everyone … [I most enjoyed] being with my friends, I made some new friends.'

	Enjoyment of robotics tasks	**Student AS04, Male, Year 8:** '[I most enjoyed] the actual robotics, I mean the actual robots, they're cool. And the sumo wrestling'. **Student AS03, Male, Year 8:** '[I most enjoyed] building and programming, the challenges.' **Parent AP03B:** 'He enjoyed himself, except for the one day he forgot it was on. He's been enthusiastic about participating. He requested a solar-powered robot for his birthday!'
	Relevance to job/career interests, life skills	**Student AS02, Male, Year 8:** 'It was good, because it will help me with what I want to do when I go to TAFE and do mechanic work there.' **Parent BP03:** 'He was comfortable with the Lego, but not so much the coding. He has done some Coding Dojo before, and he wants to be a games developer, so I hope this has shown him that he can do it. He needs to be interested to really learn and engage.'
	Fun	**Student AS01, Female, Year 8:** 'It's been fun and it's been quite amazing to have the opportunity to do robotics.'
	Generalisation to classroom and playground	**Teacher AT01:** 'I think the best thing that we've noticed would be seeing them interact with each other outside robotics … especially the verified kids, I hear them saying, "Oh are you coming [to robotics club] on Wednesday?" or seeing them sit together at lunch. That was a goal of ours, just to recognise faces and a friendship, with what they were comfortable with, so that's been really nice.' **Teacher AT02:** 'I think there are friendships that came out of that which I'm really happy about. There are a couple of partnerships of the students who were previously isolated that now we see that as a friendship group and they associate each other as good friends. So that's been really, really lovely … That was why we went in realistically for our kids, it was to see if we could give some of our more challenged students some basics to help them make friends. That was our very basic goal. So I think that that has happened.' **Teacher BT01:** 'For me what I liked to see was the way the kids interacted and that communicating with each other. Their relationships with each other.' **Parent BP07:** 'It's nice to see others initiating and interacting with him afterwards. It's been a positive socially. He's had a fantastic term this term, I'd say it has been at least partly due to robotics. In terms of confidence with other kids, and social skills. There has definitely been some positives in that area.'
Task/Technology	Building, programming and technological skills	**Student AS07, Male, Year 8**: '[We learnt] how to use the sensors, and how to program it to make it move.' **Parent AP03A:** 'He's had fun playing with the robots, and programming. He's enjoyed it and has been happy. Familiarity with technology; logical thinking; problem solving and persistence.' **Teacher BT01:** 'I liked to see them … understanding what they had to do, the programming and all that stuff.'
	Creativity and problem solving skills	**Student BS06, Male, Year 7:** 'Some imagination, you need a bit of that. And a bit of common sense about how the robot is going to move around.'
	Student-teacher relationship	**Student AS05, Male, Year 7:** '[I liked] that I had teachers … getting the teachers' trust and trying to do my work.' **Parent AP02:** 'What he's gained is having two teachers he feels he can talk to … He's now got someone in that school that no matter what is going on he can go up and talk to. For him with the autistic side I think that's massive because I've seen instances where he's been ready to blow and he will go and seek her out and have a chat to her.' **Teacher AT01 (best aspects):** 'Watching the kids' success; no matter how small that's been, that's been really important and also, remembering that those little successes happen every day in just normal life for these kids, here at this school. So that's been really big and looking at how far they've come and how robotics has aided that, in terms of them being a part of a place that is safe and where they belong and it's – yeah, it's really been a place for them to be every Wednesday and give them something extra.' **Parent BP04:** 'I think one of the big picture things out of this program that has been really good for him, has been, because it is an extra-curricular thing, the exposure and the relationships with teachers and staff at the school … It's more exposure outside the classroom. And they are lovely mentoring relationships for him.'

3.2.2.2 Time 2 – Category 2: Teacher Outcomes

The second Time 2 category to emerge was teacher outcomes. This category reflected the perceived teacher outcomes as a result of involvement in the club. Within this category, two key themes emerged from the data (see Table 9 for more details). These themes were similar to Time 2 themes and included: 1) content knowledge; and, 2) generalisation. Contained in each theme were sub themes. In relation to the content knowledge theme, three sub themes were generated including: increased knowledge of personal and social capabilities, pedagogical knowledge, and robotics and programming. Three sub themes also emerged for the theme of generalisation. Table 9 provides more details of these themes and sub themes.

Table 9 *Themes Emerging From Teacher Outcomes Category*

Theme	Sub Theme	Supporting Quotes
Content Knowledge	Increased knowledge of personal and social capabilities	*Has your own knowledge of the personal and social capabilities improved as part of this?* **Teacher AT01:** 'Definitely, yeah. I think sitting down and doing reflections and actually thinking about, okay, what happened in that hour and a bit and then looking at the scale and almost looking at, okay, so where has the … or the picture that's on the page in the booklet, what worked today and have I almost ticked them off for the day?' **Teacher AT02:** '[The personal and social capabilities are] certainly an area that I'm passionate about in terms of education generally so I'm very happy to see that in the spotlight. So hopefully that has certainly developed my awareness of it a little bit more. But perhaps just to solidify my respect for that in terms of the place in developing well rounded and confident happy young people. That's a part of the curriculum which is never acknowledged as curriculum because it's emotional rather than academic. But I think it's incredibly important.'
	Pedagogical knowledge	See also Table 11 (Themes Emerging from Teaching Actions Category) for evidence of teachers' pedagogical knowledge.
	Robotics, programming	**Teacher AT01:** 'The programming stuff … wasn't really a priority for me … especially in terms of the kids with ASD, it's not been a thing for me to worry about so much.'
Generalisation	Of pedagogy to the classroom and playground	**Teacher AT01:** 'Different strategies that have worked, all the things we wouldn't have really picked up on just teaching, that we've picked up on in the more casual environment, in robotics, we've taken that then back to class or back to their key teachers.' **Teacher AT02:** 'Hopefully shining a spotlight on [the personal and social capabilities] and saying hey, where does this fit in with your classroom, it's a cross curriculum priority so how are you bringing this into all of our classrooms or how are we embedding it in our school culture? I'd like to think that the club helps to do that.'
	Increased knowledge of individual students' needs	**Teacher AT01:** 'From a teacher's perspective, looking at it, I think we've learnt a lot about how those kids work and how they interact with each other.' **Teacher AT02:** 'It always is helpful to get some more strategies and to see how kids react in different situations because all the theory in the world doesn't save you when that child is outside on the ground crying and refusing to come inside. You've got to come up with something to do and I think the club helped us with that. I certainly got more of a personal insight into dealing with those situations.' **Teacher BT01:** 'For me overall the biggest thing, it was a real eye-opener to have – it was like a concentration of verified kids in the school all in the room at the same time. I've never experienced that. I'm not trained in dealing with it on that level. Usually you have one of them in your classroom, and – do you know what I mean? You give them attention, but not so many at once … All those things that were noticeable to me, like they don't listen when you talk to them … I guess that for me was a real eye-opener and I learnt a lot from that.'

	Teacher-student relationships	**Teacher AT01:** 'I think I would just continue having [the club] act as a place for the kids and continue really trying to pick up on what's happening in the Club each week. I know, probably to the kids they think that we just kind of stand there and watch, but it's all of the little things or just what we can hear over there or … which is what we have to do in the classroom. We can't always be one-on-one but, at the same time, we need to pick up as teachers when we need to do that. Especially for those kids who are verified, we need to be able to realise when they're struggling or when they're getting stressed or whatever and how we can influence that. We can either choose to acknowledge it and act on it or we can ignore it and it's the same in the classroom, so that's been a huge thing that I would take away. Again, not minimising the little wins or how they feel because, to them, they've probably worked on it for six weeks.'

3.2.2.3 Time 2 – Category 3: Challenges and Suggestions for Improvement

The third Time 2 category to emerge was challenges and suggestions for improvement. This category reflected the perceived challenges and suggestions for improving the club. Within this category, four key themes emerged from the data (see Table 10 for more details). These themes included: 1) social/content; 2) strategies/pedagogy; 3) task/technology; and, 4) to support generalisation. Contained in each theme were sub themes. These are outlined in more detail in Table 10.

The qualitative data suggested improvements would be useful to the social aspects of the club and the content including: improving team configuration and resolving teamwork difficulties; encouraging consistent teams and attendance; having student-led team formations; highlighting that the robot belongs to a team; having more students in the club; and, revising the learning intentions and success criteria. The data also stressed the importance of having: clear rules and expectations; fair instructions and ownership of equipment; development of positive attitudes; structure and scaffolding; scheduling and built-in flexibility; enthusiastic teachers; and, more positive reinforcement and celebration of success.

In relation to the tasks and technology, support for technical difficulties and more effective computers and wifi were highlighted. Suggestions by teachers included consideration given to the nature and variety of challenges. It was also emphasised that more creative building challenges (and less programming), more robot battles and races, new challenges and the opportunity to use different robots would be useful. Other teacher reflections included suggestions for more teaching of programming, providing more time for the club, and improving not only teacher competence and confidence with robotics but also more support.

In relation to generalisation of the skills learned, suggestions included: providing more information for parents to help keep families informed about what has happened in the club (including through a website, newsletter, email, and flyer) to assist in generating more at-home discussion; providing the opportunity for parents to attend a session/s; getting feedback from teachers; and, providing links to the classroom and broader applications. There was also a hope that the clubs would continue.

Table 10 *Challenges and Suggestions for Improvement*

Theme	Sub Theme	Supporting Quotes
Social/Content	Teamwork difficulties, team configuration	**Student AS06, Male, Year 8:** 'Sometimes I got a bit angry because there was people who just wouldn't do anything. All they wanted to do was the programming.' **Student BS06, Male, Year 7:** 'At first, none of my group would come up with any ideas and I was the only one saying "Oh how about we try this?" or "Can I try and program" but then they would come up with lame excuses about why we shouldn't do that idea or why I shouldn't do a bit of programming.'
	Encourage consistent teams and attendance	**Student AS04, Male, Year 8:** 'I was not in the same team every week … maybe just one team [would be better].' **Teacher BT01:** 'Probably be aware of who you're grouping, when you group the kids together. Just know – having background information about the kids.'
	Student-led team formation	**Student AS04, Male, Year 8:** 'Maybe just stick with the friends I want to hang out with.' **Parent AP03:** 'Perhaps thinking about the way groups of students are formed, because you want to leave them together long enough for friendships to form … giving them encouragement to switch every so often, and leaving it more up to them, but with enough of a push to overcome inertia.'
	Robot belongs to a team	**Student BS02, Female, Year 8:** 'I think at the start everyone has a personal robot, instead of you just pick up a random robot.'
	More students	**Student AS06, Male, Year 8:** 'Maybe try to get some more people to join next time. Because I knew some people who would've liked to do it, but they didn't get to do it this term.'
	Revised learning intentions/success criteria	**Teacher AT02:** 'I think it might even be more handy of "here's six goals we'd like to achieve by the end of the club" and they would all incorporate in each week … Maybe you know, at the start of the club here's this toolkit that we're going to try and develop and in our toolkit this is what we're going to talk about. We're going to talk about empathy, we're going to talk about leadership, we're going to talk problem solving, resilience or whatever our big goals are and just keep them simple. [Though] they're not simple at all!' **Teacher BT02:** Notes need for more tangible/observable success criteria to structure student reflections, and teacher observations of student behaviour.
Strategies/Pedagogy	Clear rules and expectations	**Teacher BT02:** Suggestion to provide teachers with a list of key strategies/pedagogical practices they should be using from the start. Then, teacher reflections can be structured around how well they stick to these and use these. This could be in the form of a checklist. There is a need for consistency, which is lacking in the current structure of teacher reflections.
	Fair instructions, ownership of equipment	**Student BS07, Male, Year 8:** 'Having clear rules and not taking stuff from other people's tables.'
	Positive attitudes	**Student BS06, Male, Year 7:** 'Improve the attitude towards the robotics club cause some people are just being rude when they go to robotics club. How about how certain people should be nice in there.'
	Structure, scaffolding	**Teacher AT02:** In terms of students experiencing success with the [personal and social] capability side of things I think some more structure and explicit instruction on that would be beneficial … Perhaps it was more in our implementation then the actual structure … lay it out like it's a lesson … but also keep it relaxed and fun and not "this is an extra lesson" but at the same time we're still trying to reach an objective. It's a fine balance.'

	Scheduling; built-in flexibility	**Teacher AT02:** 'Flexibility in terms of timeframe, so making sure that there's some flexibility if we are running a 12 week project or whatever, inevitably three of those weeks are going to stuff up with something. Then having the flexibility in terms of the actual activity types as well I think helps because different kids are going to be into different things. Catering to your club I guess … I just make sure that they all get that sense of success as well because some of the kids were really able and were meeting the challenge and then there were some kids who weren't just getting off the starting … Maybe you could even run it in two six week blocks or something like that rather than even a 10 week or smaller. Just because realistically the first week and last week of school [terms] are write-offs.' **Teacher BT01:** (notes from later meeting) Teacher resource was very helpful to provide structure. Reflections and focus on Personal and Social Capabilities was helpful, but didn't need Start-Stop-Continue framework. Definitely recommend more than one staff member in the room.
	Teachers' enthusiasm	**Student BS03, Male, Year 7:** 'I just want teachers to be more available to help us whenever we need it … making sure teachers have more enthusiasm.'
	More positive reinforcement/celebration	**Student AS05, Male, Year 7:** 'Perhaps we could celebrate with a takeaway meal, like pizza?' **Teacher BT01:** 'Next time I would be more positive, but I – just not really knowing the program and feeling confident all the time, I didn't pay attention to that as much as I probably should have. Those kids really need it.' **Parent BP04:** 'Maybe to formalise it too, I think it would be cool at the end if … I don't know, are they getting a little certificate or something? A bit of paper at the end that shows they did a however-many-week program, and gave away their afternoons once a week … and these are the skills – like almost a formalisation of the skills they've learned, so they can reflect back and go "Actually yeah I did do that! I did do that!"'
Task/Technology	Technical difficulties	**Student AS07, Male, Year 8:** 'When the computers had to upgrade and we couldn't do it. Or when the computers took 20 minutes just to load.'
	More effective computers/wifi	**Student AS01, Female, Year 8:** 'The wifi connection [could have been improved].'
	Nature of challenges	**Student AS02, Male, Year 8:** '[In the first few weeks] I was kind of getting a bit bored because we kind of kept doing the same thing over and over again.' **Student AS08, Male, Year 8:** 'Probably stop doing a lot of programming and do a little bit more building.'
	Variety of challenges from the start	**Student AS02, Male, Year 8:** 'Doing different things, that would be [good]. Nothing else to really improve it.'
	More creative building challenges (and less programming)	**Parent AP02:** 'The only thing I noticed with [student] was I think about midway he was starting to sort of toss up whether he wanted to keep going and I think that was once the building stopped and there was just so much programming and he was getting to the point where, okay, I'm getting sick of the programming, I like the building. That's the only other thing I can see, is that you're probably going to have some kids who really love doing the programming and other kids who like doing the building or the designing and I guess that's something that comes as the program continues on, that they might want to hone in on particular areas that interest them.' **Student BS08, Male, Year 7:** 'I think there could be more of a wide range of activities where you could actually have to modify the robot, not just its programming.' **Student BS03, Male, Year 7:** 'Just like making any type of robot you want, and you have like a lot of time to do it then after that you make a second one.'
	More robot battles and races	**Student AS09, Male, Year 8:** 'Adding more stuff to the EV3s and have more races and fights with the EV3s.'

	New challenges (e.g., dance competition, labyrinth, robocops, make it draw)	**Student AS10, Male, Year 8:** 'Getting the robot to draw, that would be cool!' **Student BS06, Male, Year 7:** 'I would have liked it if there was a bit more of the challenges, like making a labyrinth out of tape and just trying to make the robot go through it without getting caught by another robot and all that kind of stuff.'
	Opportunity to use different robots	**Student AS04, Male, Year 8:** 'What about other kinds of areas like another Lego product … maybe another robot?'
	More teaching of programming	**Teacher AT02:** 'I think it would be really handy to maybe build into the program some of those basics as well … in the first couple of weeks just a robotics 101 so that they have those basic [programming] skills … In terms of making sure – so that would address the students experiencing success with the robotics side of things.' **Student BS02, Female, Year 8:** 'The programming was very very hard … The [video] tutorial just showed you what to do, instead of you learning what to actually do … Maybe if we could have like certain days where you can come in and learn about easier program[ming]. That would make it fairly, that would be quite fun and make it a lot more easier.'
	More time	**Student AS10, Male, Year 8:** '[With the] programming, sometimes it confuses me and I need more time.' **Student AS08, Male, Year 8:** 'You could maybe make it a little bit longer, the lessons at the end of the day … So we are not rushing and getting it wrong.'
	Teacher competence/confidence with robotics, more support	**Teacher AT01:** '[Sometimes] I'd think, "oh, look, we don't know enough about robotics, why are we doing this?" I'll be honest, that's definitely been a thought at different points for us … I would like to have sat down with the programming or sat down with the challenges more than just for an hour or whatever, just to get a better grip on it all, I guess … I'd probably start doing more planning or more familiarising with what is involved, whether that's a whole day out or whatever, just to get a grip on that.' **Teacher AT02:** 'Maybe some staffing resources as well. We could potentially develop how we would teach the [programming] basics to the kids but we need the basics too … That would be my biggest pieces of feedback, would be consider building in more basics for staff and students so that then those challenges will probably naturally go better if those basics were there.'
To Support Generalisation	Information for parents	**Parent AP06:** 'Perhaps a bit more communication with parents to some degree, but you don't want to bog parents down.'
	Information throughout to help generate at-home discussion (website, newsletter, email, flyer)	**Parent AP09:** 'Maybe for future giving information to the parents on what they've done so that the parents can instigate conversation … You know maybe that's physical information about what's happening in the session going home to the parents either as an email or a flyer.' **Parent BP06:** 'I would've liked something where he was required to engage more at home in the conversation, so you can help. Because learning to work in a team is a life skill, it's not just a robotics skill. It's something you can put into everything. So if I knew there was a problem at robotics that he could identify with, then I could perhaps talk him through it a bit more … I think I prefer something ongoing in between, just so I can have those conversations with [student] around what's coming up, and prepping him for what's coming up next … it might be just on a website. "Refer to this website, this is what we're doing this coming week."'
	Opportunity to attend a session/s	**Parent BP04:** 'With parents' involvement [in sessions], rather than being just spectators, maybe they could be put into groups with or without their own children, and actually, you know, like children do peer-teaching, they could teach the parents. "This is how you do this", I don't know.' **Parent BP05:** 'In the middle and then at the end, the kids get, if they want to, to invite their parents to see their final prototype of thing … it would be interesting to see the children in front of other parents.'
	Feedback from teachers	**Parent AP03:** 'Some feedback from teachers [at the end], as a recap, would be appreciated.' **Parent AP04:** 'It would be good to speak to some teachers to clarify how he went.' **Parent BP01:** 'Something that might be beneficial for parents if you run future clubs is do you actually give them feedback on the strategies that you found their child responded to.'
	Hope the club continues	**Parent AP09:** 'I just think it's been a wonderful experience. I think it's something they should continue doing.' **Parent BP07:** 'I hope they do carry on with the Club, and with competitions, that would be good.'
	Links to classroom and broader applications	**Parent AP01:** 'Maybe more links back to the classroom, like through computers … back into tech class or something, that would be great.'

3.2.3 Time 1 and 2 Categories

Data collected at both Time 1 and 2 generated a range of additional categories. The categories reflect not only what participants' perceptions were going into the club but also things they learned along the way.

3.2.3.1 Teaching Actions

One category to emerge was teaching actions and reflected teaching actions the teachers involved in the club felt were important to be integrated into the delivery of the club. This category reflected not only ideas they had going into the club but also things they had learned along the way or as a result of retrospective reflection. Within the category of teaching actions, two key themes emerged from the data (see Table 11 for more details). These themes included: 1) pedagogy and effective strategies; and, 2) professional learning processes. Contained in each theme a number of sub themes surfaced. These are described in more detail in Table 11.

In summary, specific teaching actions that were perceived as important to the running of the club and were important to be integrated into the delivery of the club included: the use of explicit instruction; breaking tasks down; the use of structure, routine and time management; and, visual supports. It was also highlighted that there should be a learning focus with the use of: prompting, coaching, reflection, modelling and joint construction; positive reinforcement and feedback; practice and repetition; the provision of a safe environment; student-led group formation and different roles in the group; a focus on the hidden learning; allowance for differentiation; and, allowing students ownership. Professional learning processes that were highlighted included: completing reflections and planning; sharing in staff meetings; peer observation and mentoring; and, improving teacher-student relationships.

Table 11 *Themes Emerging from Teaching Actions Category*

Theme	Sub Theme	Supporting Quotes
Pedagogy and Effective Strategies	Explicit instruction, breaking tasks down	**Teacher AT02:** 'I don't think they would mind that much … "Here's our goal for today" and make it really explicit … So maybe having it slightly more explicit or spend a little more time doing it, reminding them what that looks like.'
	Structure and routine, time management	**Teacher BT02:** 'Students with autism thrive in a structured environment. Establish a routine and keep it as consistent as possible. They feel in control and secure when they know what to expect.'
	Visual supports	**Teacher BT02:** 'Visuals and written instructions rather than verbal. For example, colour-coded posters of key skills could be helpful, and assist generalisation to other contexts.'
	Learning focus: Prompting, coaching, reflection	**Teacher AT01:** 'The big focus on the positives. "What can we do to fix it?" has been one of the phrases we've tried to use or, "What do we do now?" We've tried to start with, "What do we …" and then go from there as a phrase, and tried to keep using that.' **Teacher BT01:** 'Just to say to them, "What do you think is a better way of …" Put it back on them all the time. "How can you resolve the situation?" … making them both realise what's a better way forward. So resolve the conflict that way.'
	Modelling, joint construction	**Teacher AT02:** 'I think that modelling of the conversations as they're happening as well, I guess that's kind of like a joint construction by that point anyway. So at the start of the lesson you might model what that looks like but when you're actually in the middle of the conversation mediating essentially how to have the conversation appropriately which works because for a lot of the students that's so weird, that they're happy to have you there mediating the conversation. That worked, that kind of joint construction.' **Parent BP03:** 'Scaffolding and appropriate interactions from adults. Encouraging students to put their suggestions forward.'
	Positive reinforcement, feedback	**Teacher AT02:** 'Framing things positively rather than negatively, so praising positive examples of behaviour. So if someone said "good job, hey I love how you are praising, blah, blah, blah," rather than "hey, that was a put down, please don't, that was rude."'
	Practice, repetition	**Teacher AT02:** 'In terms of the social skills I think once you've kind of made them explicit it's going to be a matter of practice and reminder and timing. That's something that hopefully, once you've made the skill explicit, just needs to continue to be modelled and practiced which comes with time.' **Parent BP04:** 'Obviously the whole Lego robotics experience was group-based, and I think hopefully not having a lot of that experience in doing group-based activities, it just gave more exposure to having to work with other children.'
	Safe environment	**Teacher AT01:** 'While there's some structure it was also, I think, how it needed to run for them, which was giving them their instructions and advice and support but in a more casual environment and comfortable for them.' **Parent AP02:** 'By working in the groups I think that's what pushed him along, and I think it's being in that safe environment.'
	Student-led group formation, different roles	**Teacher BT01:** 'What groups worked better together, and shifting them around. What we all did was negotiated with some kids, what groups they felt they would work better in.' **Parent BP02:** 'They had to work together in order to be successful, because different people had different roles. I know she felt a necessary part of her group, that her role was important.' **Student BP05:** 'I reckon you should choose your groups, 'cause maybe some people are uncomfortable with other people. Then they will at least have a fun time there.'
	Hidden learning	**Parent AP06:** 'It's been good, it's something the kids have enjoyed doing with disguised motives. I think you've done it in a clever way.'
	Allowing for differentiation	**Teacher AT01:** 'Learning how to teach here is really difficult because we've got those kids that need the structure and then there's other kids, who are also in the club, who you can let go and extend … the biggest thing is the balance.'

	Allowing students ownership	**Teacher AT02:** 'Letting the kids take ownership of the challenges and how they wanted to go about it … like when there are particular ways to do things and the students just went rogue [laughs], just letting them kind of own that ended up being more effective than stepping and trying to make it happen a particular way.'
Professional Learning Processes	Completing reflections, planning	**Teacher AT02:** 'I think the start, stop, continue [reflection] was good, I like that. That was helpful.' **Teacher BT02:** 'Start-Stop-Continue was not a helpful structure for observations. [It was] repetitive from week to week, [and it made] the key points and things to remember unclear … a list of observable behaviours [would be more helpful] … perhaps provide teachers with a list of key strategies they should be using from the start. Then, teacher reflections can be structured around how well they stick to these and use these.'
	Sharing in staff meeting, case studies vs generalisations	**Teacher AT02:** 'I think for teaching, to bring it back to the staff, hopefully seeing some of those real world examples and how we dealt with them at the time would be a lot more beneficial in terms of developing their ability to teach the capabilities than the text book would be.' **Teacher BT01:** 'I don't think the staff realise what we have done, so it's trying to get that across to them … the strategies they could take forward … it's something that we would have to sit down and think about presenting, because you can't go oh, look at this particular kid and this particular kid and this particular kid. We just have to come up with a generalisation of really good strategies for any kid that they might come across, that they might find useful … but it would be really good to have someone like me who has had the experience now with these kids for 12 weeks, passing on really good ideas.'
	Peer observation/mentoring	**Teacher AT01:** 'Hopefully it [will lead to] us observing each other's classrooms again or peer mentoring, just something like that where we're looking at the kids with ASD and how other people do it or other strategies, that we might not have thought of.'
	Teacher-student relationship	**Teacher AT01:** 'Picking up on the social cues or knowing the students and knowing what are the triggers for behaviour or language or someone being upset and then, picking up on that in class and not shutting it down but acknowledging it.' **Teacher AT02:** 'Having built a relationship with us a little bit more I think he does respond to our management of his breakdown and realises that it's just not going to fly and that he's safe and that it's okay to be upset.'

4. Summary of Key Findings

This pilot study further expanded and evaluated a robotics social club intervention to support the inclusion of young people on the spectrum within inclusive school contexts. The study developed a manual and supporting resources and documentation that would allow teachers in other schools to establish and implement a robotics social club. In addition, these resources assist in capturing and generalising the learnings and strategies acquired within the club more broadly to the classroom and whole school context and to support the personal and social capabilities of the Australian Curriculum.

KEY FINDINGS FROM THE RESEARCH

Key findings of this pilot study utilising robotics social clubs to support the needs of students on the autism spectrum within inclusive school settings are now discussed.

4.1 SOCIAL NETWORKS AND FRIENDSHIPS

- Rather than forming *more* connections with peers, it appears the club encouraged students to establish *stronger* friendships in more clearly defined groups. Both students on the spectrum and their same aged peers appeared to show a similar trend.
- Overall, students on the autism spectrum:
    - Demonstrated an increased awareness of peer social networks.
    - Experienced greater benefit in terms of their integration and acceptance into the social network of the club, compared to their same aged peers.
    - Experienced greater benefits than their peers, in terms of an increase in the number of students they liked to hang out with, and a decrease in the number of times they were ‘rejected’ by peers.
- In terms of friendships, both students on the autism spectrum and their same aged peers showed a comparable increase over time in the number of nominations as ‘friends’ by peers. However, same aged peers showed a

greater increase in their awareness of friendships and social networks compared to students on the spectrum.

4.2 MOTIVATION AND ENGAGEMENT

- Initial findings suggest that the club may have had a positive effect on students' motivation and engagement by buffering against some of the expected drops in 'booster' factors over time as students get older.
- The club seemed to have a positive effect on engagement by buffering against the expected drop in engagement over time, and perhaps even helping to increase levels of engagement in the most vulnerable students.

4.3 PERCEPTIONS OF THE CLUB

4.3.1 Expectations Coming into the Club

There were a range of teacher, parent and student perceived expectations of the club prior to it commencing. These expectations centred around how involvement would support the students involved and the skills teachers would require.

4.3.1.1 Perceptions of how the club would help the students involved

Perceptions of how the club would help the students involved included:

1. **Enhancing personal and social capabilities** including:
    a. Developing skills needed for teamwork,
    b. Increasing confidence, having a sense of success and developing leadership skills,
    c. Enhancing resilience and dealing with frustrations,
    d. Increasing self-awareness and independence, and
    e. Getting to know others and making friends.
2. **Increasing engagement** including:
    a. Enhancing student-student relationships (e.g., getting to know others and making new friends),

b. Having relevance to job and career interests and developing life skills,

c. Having fun,

d. Increasing co-curricular involvement, and

e. Encouraging generalisation to classroom and playground.

3. **Tasks and technology** including:

    a. Increasing building, programming and technological skills, and

    b. Enhancing **c**reativity and problem solving skills.

4.3.1.2 Perceptions of expectations on teachers involved in the club

These expectations centred around things teachers would need to run the clubs or skills they would require and included:

1. **Pedagogical knowledge** including a focus on teachers running the club:

    a. Using explicit instruction and breaking down tasks,

    b. Providing structure and routine,

    c. Utilising:

        i. Visual supports,

        ii. Prompting, coaching, reflection,

        iii. Modelling,

        iv. Positive reinforcement and feedback,

        v. Practice and repetition,

    d. Providing a safe environment,

    e. Teaching confidence and encouraging self-efficacy, and

    f. Having a desire to learn new pedagogical practices.

2. **Content knowledge** focussed on an expectation that some existing knowledge of the personal and social capabilities existed and would be utilised.

3. **Technological knowledge expectations** highlighted the need for teachers to be supported in their technological and content knowledge to help the club be successful.
4. **Generalisation** expectations highlighted the importance of generalising the student learning from the club to both the classroom and playground. Expectations of generalisation to other teachers' practice included that this could be through:
    a. staff meetings,
    b. the sharing of case studies of students,
    c. peer observation and mentoring, and
    d. informal conversations.

4.3.2 Perceptions of the Outcomes of the Club

Perceptions of the outcomes of the club fell into three main categories:

1. Student outcomes,
2. Teacher outcomes, and
3. Challenges and suggestions for improvement.

4.3.2.1 Student Outcomes

The perceived benefits of the club for the students involved included improvements in:

1. **Personal and social capabilities** including:
    a. Improved skills in teamwork skills (e.g., being cooperative, helpful, patient, sharing, communicating, listening, caring, compromising/making decisions, including others),
    b. Increased confidence, having a sense of success and improved leadership skills,
    c. Enhanced resilience and better skills in dealing with frustrations,
    d. Improved self-awareness of strengths and difficulties, and

e. Increased knowledge of others and development of friendships.

2. **Increased engagement** including:

    a. Improved student-student relationships (e.g., got to know others, made new friends),

    b. Enjoyment of robotics tasks,

    c. Relevance to job and career interests was obvious and life skills were learned,

    d. It was fun, and

    e. There was generalisation to classroom and playground.

3. **Task/technology** including:

    a. Building, programming and technological skills were learned,

    b. Creativity and problem solving skills improved, and

    c. Student-teacher relationships were improved.

4.3.2.2 Teacher Outcomes

The perceived benefits of the club for the teachers involved included improvements in:

1. **Content knowledge,** including increased knowledge in:

    a. personal and social capabilities,

    b. pedagogical knowledge, and

    c. robotics and programming.

2. **Generalisation** including:

    a. to the classroom and playground,

    b. increased knowledge of individual students' needs, and

    c. improved teacher-student relationships.

4.3.2.3 Challenges and Suggestions for Improvement

There was also a lot of feedback about the challenges experienced and suggestions for improvement to the club and resources. These included improvements to the:

1. **Social aspects of the club and the conten**t including:
    a. Teamwork difficulties and improving team configuration,
    b. Encouraging consistent teams and attendance,
    c. Having student-led team formation,
    d. Reinforcing that the robot belongs to a team,
    e. Having more students, and
    f. Revising the learning intentions and success criteria.
2. **Strategies and pedagogy** including the importance of having:
    a. Clear rules and expectations,
    b. Fair instructions and ownership of equipment,
    c. Development of positive attitudes,
    d. Structure and scaffolding,
    e. Scheduling and built-in flexibility,
    f. Enthusiastic teachers, and
    g. More positive reinforcement and celebration of success.
3. **Tasks and technology** including:
    a. Support for technical difficulties,
    b. More effective computers/wifi,
    c. Consideration given to:
        i. The nature of challenges,
        ii. The variety of challenges from the start,

iii. More creative building challenges (and less programming),

iv. More robot battles and races,

v. New challenges, and

vi. Opportunity to use different robots,

d. More teaching of programming,

e. Providing more time for the club, and

f. Improving teacher competence/confidence with robotics, more support.

4. **Generalisation of the skills learned** including providing:

a. Information for parents,

b. Information provided to families to help generate at-home discussion (including through a website, newsletter, email, flyer),

c. The opportunity to attend a session/s,

d. Feedback from teachers,

e. Hope that the club continues, and

f. Links to classroom and broader applications.

4.4 Teaching Actions

Specific teaching actions that were perceived as important to the running of the club and were important to be integrated into the delivery of the club included:

1. **Pedagogy and effective strategies** including the use of:

a. Explicit instruction, breaking tasks down,

b. Structure and routine, time management,

c. Visual supports,

d. A learning focus with the use of:

i. Prompting, coaching, reflection,

ii. Modelling, joint construction,

iii. Positive reinforcement and feedback,

iv. Practice and repetition,

v. The provision of a safe environment,

vi. Student-led group formation and different roles in the group,

vii. A focus on the hidden learning, and

viii. Allowing for differentiation and allowing students ownership.

2. **Professional learning processes** including:

    a. Completing reflections, planning,

    b. Sharing in staff meeting,

    c. Peer observation and mentoring, and

    d. Teacher-student relationships.

5. Limitations

Limitations of this pilot study include:

- The limited timeframe for the study;
- The small sample size due to it being a pilot/exploratory study. This prevented more powerful analyses of intervention effects and influences the ability to generalise the results; and,
- In relation to the use of the *Social Responsiveness Scale* (Constantino & Gruber, 2012), the results were likely influenced or confounded by differences in raters within and between schools. This was unavoidable due to nature of the current study as participatory action research, and the need to listen and respond to the school's preferences in the implementation of the research (to a reasonable extent).

6. Implications

6.1 IMPLICATIONS FOR FUTURE RESEARCH

Now that the current study has informed the development of resources, larger scale studies are necessary to evaluate the efficacy of the intervention and, more importantly, its effectiveness across a wider range of school settings and age groups. Furthermore, consideration should be given to:

- Future studies to investigate the impact of robotics social clubs for students on the spectrum in relation to:
    - school connectedness for students on the spectrum;
    - academic motivation and engagement, but broader and more relevant to mental health and social-emotional wellbeing focus outcomes, in addition to academic/educational outcomes;
    - social-emotional wellbeing; and,
    - academic/educational outcomes.
- Future studies to use a measure of social skills and deficits (e.g., Social Skills Improvement System Rating Scales) rather than a measure of ASD symptomatology (i.e., SRS-2). This would better capture the construct/skills targeted through the intervention.
- Future studies to investigate effectiveness/application of an interactive learning community component to the robotics social club's website. The study could focus on encouraging and enabling teachers to contribute to and learn from each other's knowledge and experiences, and encourage networking between schools, such that the resource is constantly evolving.

6.2 IMPLICATIONS FOR FUTURE PRACTICE

Implications for future practice include:

- Considering using Lego robotics clubs as part of the continuum of support offered through a positive behaviour framework. The club framework would fit in well at both a Tier 1 or 2 level intervention.
- Though resources have been developed with the intention of being detailed enough and with enough links to external resources for teachers to pick up and run the robotics social club program, consideration should be given to the need to provide a day of training before implementing the program. This training could:
    - Provide an overview of the program;
    - Develop content knowledge (personal and social capabilities);
    - Develop technological knowledge (robotics); and,
    - Develop pedagogical knowledge (re: effective practices for teaching students on the spectrum).
- Provide examples of how application/integration of the club within existing school systems and policies could be applied (e.g., within a school's Student Behaviour Support Plan as a Tier 1 or Tier 2 targeted social skills intervention, and within the Australian Curriculum requirements). This could demonstrate how establishing a robotics social club within a school can meet multiple goals – it is relevant not only to inclusive education and supporting students on the autism spectrum, but also to supporting broader student wellbeing and supporting all students to meet achievement standards across multiple areas of the Australian Curriculum.

6.3 KEY RECOMMENDATIONS

1. Robotics social clubs can serve multiple goals in school environments including to support:
    a. Social emotional wellbeing,

b. Behaviour support,

c. Academic engagement and motivation, and

d. The demands of the Australian curriculum.

2. Professional development for teachers implementing robotics social clubs in schools would be useful and could be offered in a range of ways (e.g., face-to-face, through website or social networking community).
3. Resources need to be constantly updated and improved to reflect learnings from school communities implementing them.
4. Robotics social clubs have application with a range of age groups, student needs and school contexts.
5. Robotics social clubs are effective to implement within inclusive school communities and help to support an inclusive school culture.

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